IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

VOLKSWAGEN GROUP OF AMERICA, INC.,
Petitioner

v.

YECHEZKAL EVAN SPERO,
Patent Owner

Case IPR2023-00197
U.S. Patent No. 10,894,503

DECLARATION OF JIANZHONG JIAO, PH.D., IN SUPPORT OF PETITIONER'S REPLY

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VWGoA EX1051
VWGoA v. Spero
IPR2023-00197

TABLE OF CONTENTS

I. INTRODUCTION 1

II. LEVEL OF ORDINARY SKILL IN THE ART 5

III. LEGAL STANDARDS 7

IV. DR. TURK HAS SHOWN THAT HE IS NEITHER AN EXPERT NOR A POSA IN THE RELEVANT FIELD, AND NEVER HAS BEEN. 7

A. Dr. Turk acknowledges he does not understand basic concepts related to automotive lighting, and lighting in general, is not aware of major projects and technical events in the relevant art, and separately accepts my knowledge and expertise in the field. 8

1. Dr. Turk has shown he does not understand basic terms a POSA would have understood within the field of automotive lighting and lighting control. 8

2. Dr. Turk has shown he is not familiar at all with basic developments in controllable headlamps, including, for example, the major EUREKA project and technical events, etc. 19

3. Dr. Turk acknowledges my expertise when discussing considerations of a POSA—and even though he cites several papers I co-authored, he ignores their substance and does not appreciate what a POSA would actually have understood. 21

B. I am convinced that Dr. Turk's inadequate, tangential experience related to self-driving systems is not adequately relevant to the subject technology to qualify him as a POSA. 25

V. DR. TURK DOES NOT UNDERSTAND THE FUNCTIONS AND BENEFITS OF A SPATIAL LIGHT MODULATOR. 30

A. Spatial light modulators were well-known structures and provided additional functionality to LED-based headlamps. 30

B. Beam's system includes both an LED array and a spatial light modulator, contrary to Dr. Turk's demonstrably false assertions.....34

C. Karlsson's system also includes both an LED array and a spatial light modulator, contrary to Dr. Turk's demonstrably false assertions. 36

VI. DR. TURK'S SUBSTANTIVE ARGUMENTS AGAINST BEAM-THOMINET ARE INCORRECT, AT LEAST IN PART BASED ON HIS MISUNDERSTANDING OF THE ART. 38

A. Beam-Thominet discloses at least three directional light sources aimed at different angles, as recited in [20.2]. 38

1. Beam's microbeam sources are "directional light sources." ... 38

2. Thominet's headlights include "at least three directional light sources aimed at different angles." 43

B. Beam-Thominet's automotive adaptive headlight system uses a processor to determine, within a field-of-view, a first-subsection including a detected vehicle and a second subsection not including a detected vehicle, to reduce glare, as recited in [20.9-20.13]/[59.7]. 44

1. Beam's automotive adaptive headlight system includes a processor determining the "first-subsection" of claim 20. 44

2. Beam's automotive adaptive headlight system includes a processor determining the "second-subsection" of claim 20... 49

C. A POSA would have been motivated to combine Thominet's curved substrate with Beam's LED array. 51

D. A POSA would have been motivated to combine Thominet's multiple directional beam segments with Beam's adaptive headlight system with a reasonable expectation of success. 53

1. Beam's and Thominet's headlight control systems are fully compatible. 54

2. Beam-Thominet's headlight provides sufficient forward illumination by actively directing beam segments for each particular driving function. 58

3. Beam-Thominet's lamp/LED/SLM controls the angular position of each microbeam to achieve different light beam patterns. 61

E. The Beam-Thominet combination discloses claim 25. 63

VII. PO'S SUBSTANTIVE ARGUMENTS AGAINST THE BEAM-THOMINET-STAM COMBINATION FAIL. 65

A. Beam's automotive adaptive headlight includes a processor determining "light output" that "illuminates the first subsection below a predefined illuminance" [59.8]–[59.9]. 66

B. A POSA would have been motivated to combine Stam's predefined low-beam illuminance level with Beam-Thominet. 68

C. Beam-Thominet-Stam combination discloses claim 64. 68

VIII. PO'S SUBSTANTIVE ARGUMENTS AGAINST THE BEAM-THOMINET-KOBAYASHI AND BEAM-THOMINET-STAM-KOBAYASHI COMBINATIONS FAIL. 70

A. The Beam-Thominet-Kobayashi combination renders obvious a headlight configured to "increase illumination in a direction of the road curvature." 71

B. Beam-Thominet-Stam-Kobayashi combination renders every limitation of claims 60-62 obvious. 74

IX. PO'S SUBSTANTIVE ARGUMENTS AGAINST THE KARLSSON-HARBERS COMBINATION FAIL. 76

A. The Karlsson-Harbers combination discloses at least three directional light sources aimed at different angles, as recited in [20.2]. 76

1. Karlsson's spotlight sources are "directional light sources." .. 76

2. Harbers's curved substrate includes "at least three directional light sources aimed at different angles." 81

B. Karlsson's automotive adaptive headlight system includes a processor determining a "first subsection" [20.9]/[59.7]. 82

C. A POSA would have been motivated to combine Harbers's curved substrate with Karlsson's spotlight array. 86

D. A POSA would have been motivated to combine Harbers's multi-function beam segments with Karlsson's adaptive headlight system to improve driver visibility. 88

1. Dr. Turk misunderstands Karlsson's "optimally adapted" beam. 90

2. Harbers's colored LEDs are compatible with Karlsson. 94

3. My First Declaration explained with sufficient particularity how to combine the teachings of Harbers's software and hardware controls with Karlsson's adaptive headlight system. 96

E. Karlsson-Harbers combination discloses claim 64. 97

X. PO'S SUBSTANTIVE ARGUMENTS AGAINST THE KARLSSON-HARBERS-GOTOU COMBINATION FAIL. 98

A. Dr. Turk's arguments that Karlsson's grid of spotlight sources default to "full illumination" are incorrect. 99

B. The Karlsson-Harbers-Gotou combination would not suffer from color-shifting issues. 103

C. Karlsson-Harbers-Gotou combination renders every limitation of claims 60-62 obvious. 105

XI. CONCLUSION 106

I, Dr. Jianzhong Jiao, hereby declare as follows.

I. INTRODUCTION

1. I have been asked by Volkswagen Group of America, Inc. ("VWGoA" or "Petitioner") to provide my opinions in the above-captioned *inter partes* review ("IPR") proceeding involving U.S. Patent No. 10,894,503 ("the '503 patent," EX1001). I previously submitted a declaration (EX1003) in support of the Petition for *inter partes* review of the '503 patent. This declaration is in support of Petitioner's Reply to Patent Owner's Response in the same proceeding, IPR2023-00197.

2. I understand that Patent Owner Yechezkal Evan Spero ("Patent Owner") submitted a Patent Owner Response ("POR," Paper 18) along with a Second Declaration from Matthew A. Turk, Ph.D. (EX2006) in support of the POR.

3. My background and qualifications were provided in paragraphs 9-20 of my First Declaration, Exhibit 1003, and my CV was submitted as Exhibit 1004. My statements and opinions in my First Declaration regarding my review of the '503 patent and related materials remain unchanged. In reaching my opinions in this declaration, I reviewed the POR, my First Declaration, and the materials reviewed as part of my First Declaration. EX1003, ¶21 (listing references

considered in my First Declaration). In addition, I reviewed and refer to the following materials:

Paper/ Exhibit No.	Description
13	Institution Decision
18	Patent Owner's Response
1052	Transcript of the Deposition of Matthew A. Turk, Ph.D., in IPR2023-00197 regarding U.S. Patent No. 10,894,503
1053	Transcript of the Deposition of Matthew A. Turk, Ph.D., in IPR2023-00315 regarding U.S. Patent No. 9,955,551
1054	Transcript of the Deposition of Matthew A. Turk, Ph.D., in IPR2022-01586 regarding U.S. Patent No. 11,208,029
1055	Intentionally left blank
1056	Moddel, G., Spatial Light Modulators: Processing Light in Real Time, *Optics and Photonics News*, pp. 17-21 (March 1997)
1057	U.S. Patent No. 6,132,072 to Turnbull et al.
1058	U.S. Patent No. 5,754,217 to Allen
1059	U.S. Patent No. 6,195,136 to Handschy et al.
1060	Intentionally left blank
1061	Intentionally left blank
1062	U.S. Patent No. 4,907,044 to Schellhorn et al.

Paper/ Exhibit No.	Description
1063	Leighty, et al., "Developing Technologies for Army Autonomous Land Vehicles (U)," Army Engineer Topographic Labs, Fort Belvoir, October 1985 (accessible online at https://apps.dtic.mil/sti/tr/pdf/ADA187972.pdf, last accessed October 30, 2023)
1064	Lowrie, et al., "The Autonomous Land Vehicle (ALV) Preliminary Road-Following Demonstration," Proceedings of SPIE, Vol. 579 Intelligent Robot and Computer Vision, 1985 (accessible at https://home.ttic.edu/~mturk/pubs/ALVpreliminary-SPIE1985.pdf, last accessed October 30, 2023)
1065	Surface Vehicle Recommended Practice, SAE International, J1383, May 2018
1066	Standard No. 108; Lamps, reflective devices, and associated equipment, 49 C.F.R. § 571.108 (November 3, 2023)
1067	Terminology: Motor Vehicle Lighting, SAE J387, November 1987
1068	"The International System of Units (SI)," Bureau International des Poids et Mesures, 7th Edition (1998) (Excerpt)
1069	Surface Vehicle Standard: Color Specification, SAE International, J578, February 2019
1070	Second Declaration of Matthew A. Turk, Ph.D. in IPR2023-00315 regarding U.S. Patent No. 9,955,551
2001	First Declaration of Matthew A. Turk, Ph.D. ("the First Turk Declaration")
2006	Second Declaration of Matthew A. Turk, Ph.D. ("the Second Turk Declaration")

Paper/ Exhibit No.	Description
2010	Jianzhong Jiao and Ben Wang, "Etendue Concern for Automotive Headlamp Using LEDs," SPIE Proceedings Vol. 5187, (January 2004) (Available at https://www.spiedigitallibrary.org/conference-proceedings-of-spie/5187/0000/Etendue-concerns-for-automotive-headlamps-using-white-LEDs/10.1117/12.504363.short)
2011	Michael Bass, *Handbook of Optics* 3RD Edition Volume II, (McGraw-Hill, 2010) (Available at https://www.worldcat.org/title/555545456)
2012	Ben Wang and Jianzhong Jiao "Studies for Headlamp Optical Design Using LEDs," SAE Technical Paper Series 2004-01-0434, (March 2004) (Available at https://www.sae.org/publications/technical-papers/content/2004-01-0434/)
2013	Ben Wang and Jianzhong Jiao "Optical Transform Limitations in Headlamp Photometric Performance," SAE Technical Paper Series 2005-01-0861, (April 2005) (Available at https://www.sae.org/publications/technical-papers/content/2005-01-0861/)
2015	Jianzhong Jiao and Ben Wang "High-Efficiency Reflector Optics for LED Forward Lighting," SPIE Proceedings Vol. 6670, (September 2007) (Available at https://www.spiedigitallibrary.org/conference-proceedings-of-spie/6670/66700M/High-efficiency-reflector-optics-for-LED-automotive-forward-lighting/10.1117/12.730524.short)
2016	Navigant Consulting "Energy Saving Estimates of Light Emitting Diodes in Niche Lighting Applications" Building Technologies Program Office of Energy Efficiency and Renewable Energy U.S. Department of Energy (September 2008) (Available at Energy Savings Estimates of Light Emitting Diodes in Niche Lighting Applications (Technical Report) | OSTI.GOV.)
2017	PCT Publication No. WO 86/05147 to Flaaten
2018	Transcript of Deposition of Jianzhong Jiao, Ph.D. taken on August 23, 2023

Paper/ Exhibit No.	Description
2019	Alliance for Automotive Innovation website retrieved September 11, 2023 https://www.autosinnovate.org/about/our-members
2020	Michael Bass, *Handbook of Optics* 3RD Edition Volume V, (McGraw-Hill, 2010) (Available at https://www.worldcat.org/title/557121959.)
2021	Texas Instruments/Digikey "How DLP Technology Works," (Available at https://www.digikey.com/en/product-highlight/t/texas-instruments/dlp-technology.) (Accessed September 12, 2023.)
2022	Texas Instruments "Introduction to +/- 12 Degree Orthogonal Digital Micromirror Devices (DMDs) (Available at https://www.ti.com/lit/an/dlpa008b/dlpa008b.pdf?HQS=dis-dk-null-digikeymode-dsf-pf-null-wwe&DCM=yes&distId=10) (Accessed September 12, 2023.)

4. I have reviewed all other materials cited herein. I confirm that to the best of my knowledge the accompanying exhibits are true and accurate copies of what they purport to be, and that an expert in the field would reasonably rely on them to formulate opinions such as those set forth in this declaration.

5. My work in this case is being billed at a rate of $400 per hour, with reimbursement for actual expenses. My compensation is not contingent upon the outcome of this proceeding.

II. LEVEL OF ORDINARY SKILL IN THE ART

6. I incorporate by reference my opinion of the person of ordinary skill in the art ("POSA") as set forth in paragraphs 42-44 of my First Declaration

(EX1003), particularly that a POSA at the time of the alleged invention "would have had a bachelor of science (B.S.) degree in mechanical engineering, electrical engineering, optical engineering, applied physics, or an equivalent field, as well as at least 2 years of industry experience in the area of automotive lighting and lighting-control systems." EX1003, ¶42 (emphasis added throughout unless I note otherwise).

7. I understand that Dr. Turk agrees with my opinion regarding the level of ordinary skill, except with removing the qualifier "at least" and set the level of experience at two years to be consistent with Board's adopted qualifications EX2006, ¶¶55-58; EX1052, 23:7-19; ID, Paper 18, 7.

8. After reviewing the First Turk Declaration (EX2001), the Second Turk Declaration (EX2006), the transcript of the Turk Deposition for this proceeding (EX1052), the transcript of the Turk Deposition in the IPR of the related U.S. patent 9,955,551 ("the '551 patent," EX1053), and the transcript of the Turk Deposition in the IPR of the related U.S. patent 11,208,029 ("the '029 patent," EX1054), I am convinced that Dr. Turk is neither an expert in the relevant art, nor is he a POSA.[1] Rather he has shown through his lack of knowledge (as I explain throughout this declaration) and lack of experience that he has never been an

[1] The '029 patent is a continuation of the '503 patent, which is in turn a continuation of the '551 patent. EX1001, (63).

expert, or a POSA, as laid out and accepted by him. EX2006, ¶¶55-58; EX1053, 23:7-19. More specifically, Dr. Turk does not have two years of industry experience in the area of automotive lighting and lighting-control systems, which he acknowledges a POSA would have had. EX2006, ¶¶55-58; EX1053, 23:7-19. Accordingly, in my opinion Dr. Turk is not qualified to opine in this matter as an expert or from the perspective of a POSA.

III. LEGAL STANDARDS

9. I incorporate by reference my understanding of the legal principles, including my discussion of claim construction and obviousness, as set forth in my First Declaration. EX1003, ¶¶22-41.

IV. DR. TURK HAS SHOWN THAT HE IS NEITHER AN EXPERT NOR A POSA IN THE RELEVANT FIELD, AND NEVER HAS BEEN.

10. Again, after reviewing the First Turk Declaration (EX2001), the Second Turk Declaration (EX2006), and the transcript of the Turk Deposition in this proceeding (EX1052), the transcript of the Turk Deposition in the IPR of the related ’551 patent (EX1053), the transcript of the Turk Deposition in the IPR of the related ’029 patent (EX1054), and Dr. Turk’s CV (EX2002), each indicates to me that Dr. Turk is neither an expert in the relevant art, nor is he a POSA. Rather he has shown through his lack of knowledge and experience that he has never been an expert, or a POSA, and is not qualified to opine on what a POSA would have

understood either in the individual references here, the '503 patent itself, or the proposed obviousness combinations.

A. Dr. Turk acknowledges he does not understand basic concepts related to automotive lighting, and lighting in general, is not aware of major projects and technical events in the relevant art, and separately accepts my knowledge and expertise in the field.

11. In the sections below, I explain several aspects in which Dr. Turk has indicated to me that he is not, and never has been, a POSA under the definition that he has agreed with and adopted in this proceeding.

1. Dr. Turk has shown he does not understand basic terms a POSA would have understood within the field of automotive lighting and lighting control.

12. As I previously opined, none of the claim terms require specific construction and should receive their plain and ordinary meaning in the context of the '503 patent specification. EX1003, ¶¶67-73. I recognized that Patent Owner submitted a proposed claim construction of the term "light source" in a reexamination proceeding involving the '551 patent. EX1003, ¶¶69-71. I explained that the proposed construction of Patent Owner in the reexamination proceeding involving the '551 patent would not be applicable here. EX1003, ¶¶69-71. The Board did not "engage in any claim constructions" in its Institution Decision but interpreted the term "light source" to mean "any system that is capable of receiving an electrical signal and producing light in response to the signal." DI, Paper 13, 8.

Further, Dr. Turk repeatedly has indicated that he does not understand the plain and ordinary meanings of several claim terms.

13. For example, Dr. Turk appears to not understand what the term "intensity" means in the context of automotive lighting and lighting control. When asked for his understanding of "reduce intensity," as it relates to one of the '551 patent claims, he answered "[i]t's to reduce from one level of illumination to a lower -- change from one level of illumination to a lower level of illumination." EX1053, 72:13-17. It is not clear to me what Dr. Turk is discussing here, but I do not believe it is the concept of intensity as would be understood by a POSA. Instead, it seems he is discussing the concept of brightness of the light here based on his discussion of changing a "level of illumination," because that phrasing appears to be referencing the brightness of the light.

14. Similarly, in a deposition of the related '029 patent, when Dr. Turk was asked during his deposition, "[w]hat does 'maximum intensity' mean in the context of automotive lighting?" he answered "In general, *I don't know….I think* it means you can't make it any brighter, any higher in terms of its intensity." EX1054, 103:13-20. Dr. Turk was asked as a direct follow up: "You said, though, that you don't know in general what 'maximum intensity' means in the context of automotive lighting?" and he answered "Not as a general term in all circumstances, no." EX1054, 103:22-25.

15. But, in the automotive lighting context, a POSA would have readily understood that "intensity" refers to luminous intensity measured in the unit candela (cd) in the International System of Units. EX1068, 18. The candela value is a measurement of luminous flux per unit solid angle emitted by a light source *in a particular (or a given) direction*. It is a quantitative measurable widely known and regularly used by a POSA in the field of lighting including automotive lighting. It is not, contrary to Dr. Turk's misunderstanding, an illumination brightness level or similar to or synonymous with "brightness," which is a human perception measurement. *See* EX1054, 62:18-25.

16. Dr. Turk's misunderstanding of the term "intensity," in the context of automotive lighting, is also present in his declarations in this proceeding. For example, paragraphs 61 and 62 in the Second Turk Declaration relating to Beam's "maximum intensity" further clarify that he was conflating brightness (perception) and intensity (measured physical and physiological quantity that *includes directionality*). EX2006, ¶¶61-62, citing EX1005, 6:40-44, 3:8-15.

17. Dr. Turk also incorrectly stated that "beam pattern" is "related to brightness and darkness of illumination within the shape." EX1054, 43:2-4. Like the '029 and the '551 patent claims, features of the '503 patent claims aim to control the beam pattern, for example, by "aim[ing] illumination in a direction of the road curvature" as recited in claim 60. EX1001, 102:43-45. This makes Dr.

Turk's misunderstanding of this fundamental highly relevant. And this also directly conflicts with the Second Turk Declaration here (EX2006, ¶26), where he quotes *from an article that I co-authored*, where I explained that "[a]ny automotive headlamp beam pattern, either high-beam or low-beam, is a light luminous intensity (candela) angular distribution." EX2010, 237. Such a misunderstanding and contradiction indicates to me that he does not understand the art, relevant literature, regulations, etc., that a POSA would possess. I am convinced he has never had the knowledge of a POSA.

18. Indeed, for automotive lighting—specifically for headlamps—beam pattern includes directionality, and a change in beam pattern includes a change in direction of the light. EX2010, 237; EX1017, FIGs. 1 and 3-5. For example, for headlamps with at least both high beam and low beam functions, a POSA would understand that high beam and low beam are aimed in *different* directions. EX2010, 237; EX2012, 8, FIGs. 11A, 11B; EX2013, 7. That is, high beam and low beams have different "maximum intensities," and such "maximum intensities" must be understood also with regard to the change in beam pattern and direction. Dr. Turk has acknowledged that he does not understand such beam patterns, or their foundation in the FMVSS that he cites (without any understanding, much less that of a POSA in automotive lighting and lighting control). *See* EX1054, 42:23-43:9.

19. I previously explained the concept of beam pattern in my First Declaration, for example, in the context of adaptive headlamps and adaptive front lighting systems. EX1003, ¶¶45-59. As an example, I previously explained with reference to background art Hogrefe at paragraph 55 of my First Declaration (EX1003) that as an example, Hogrefe shows how known adapted light patterns can increase safety on curved roads, at high speeds, and within cities, for example, by varying improved lateral illuminance (shaping light around curves), increasing length of the beam to improve visibility, and expanding the beam shape to capture a wider angle, for example. And as Hogrefe's Figure 3 explains, "the individual light *pattern* of multiple sub-units sum up to the total adaptive light pattern." EX1017, FIG. 3 (emphasis in original).

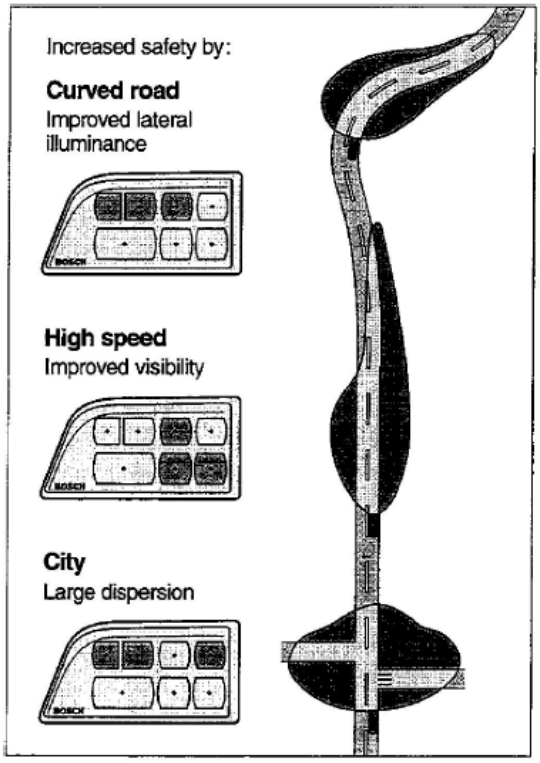


Fig.1: Three standard driving situations with adapted light pattern seen from the bird eye's view.

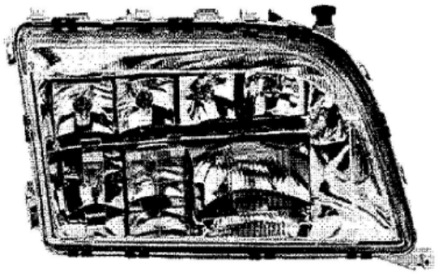
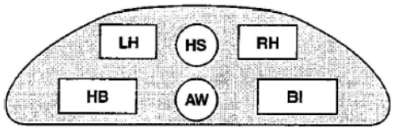


Fig 4: ALP *headlamp* sample



Single components:

LH Left hand bend
RH Right hand bend
HB High beam
BI Basic illumination
AW Adverse weather illumination
HS Hot spot

Fig. 5 Advanced ALP sample layout

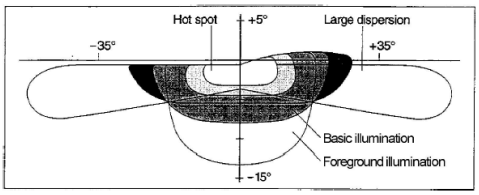


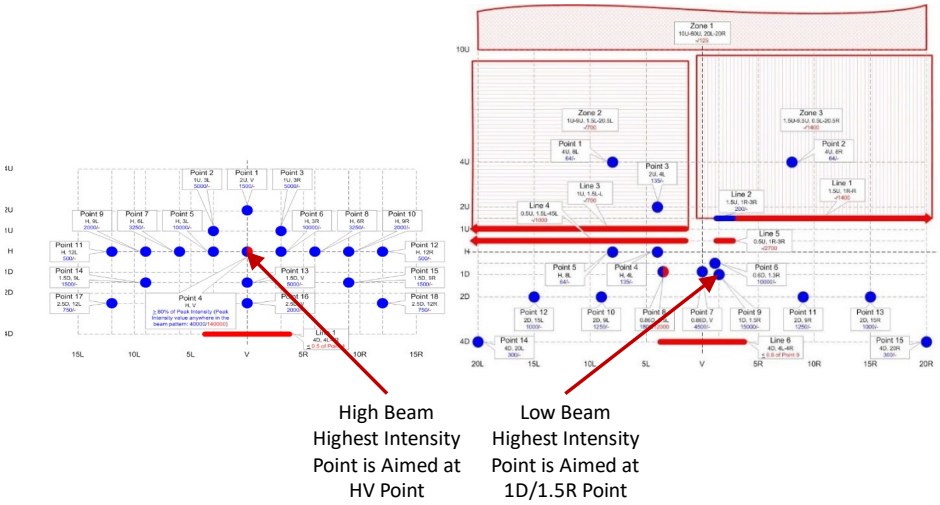
Fig. 3: Light pattern of multiple beam *headlamp* (*Isolux* curves in wall projection):
The individual light *pattern* of multiple sub-units sum up to the total adaptive light pattern

EX1017, FIGs. 1 and 3-5.

20. As shown above, the headlamp beam pattern includes variation in light direction and projected length and width on the road from a bird's eye view (in EX1017, FIG. 1) or driver's view, with intensity points along a projected distance (in EX1017, FIG. 3). Known patterns include large dispersion, curved-road light, and high speed long reaching beams as shown above.

21. A POSA would also have understood, for example, that high beams' hotspot, the highest light intensity point is aimed at the so called "HV point" – the center of the vehicle; while low beams' hotspot, the highest light intensity point is aimed in a different direction (specifically, aimed at 1-degree down and 1.5-degree

right point), per U.S. regulation FMVSS 108 as well as industry standard SAE J1383) – not the center of the vehicle but toward the right-hand side, for right-hand side drive as in the U.S., as I have illustrated in Figures 5 and 6 below:



EX1065, FIGs. 5 and 6 (Headlamp Beam Pattern Comparison of the U.S. High Beam and Low Beam, annotated).

22. Indeed, Dr. Turk seems not to be familiar with any standards with respect to vehicle headlamp glare, much less SAE J1383 or FMVSS 108:

> Q. Do you know, in the context of automotive headlamps, if there is any standard that regulates the level of permissible glare to oncoming vehicles?
>
> A. I believe there probably are such standards. I don't know them in detail.

EX1053, 65:22-66:1.

23. A POSA would have readily understood the standard and regulation requirements for headlamp glare, in particular for low beam headlamps. The red-colored testing lines and zones in the above (right) figure are the clear indications in SAE J1383 and FMVSS 108 for the maximum intensity (candela value) allowed for the purpose of glare light control. A POSA also would have understood that the automotive lamp features or functions can be "optically combined," within the applicable standards and regulations contrary to Dr. Turk's inaccurate assertion that "a POSA would not have considered combining features from lamps having different functions…, fog lamps, or cornering lamp," (EX2006, ¶26), because such combinations have routinely been allowed and practiced. *See*, *e.g.*, EX1066, 4, (noting in its definitions that "[o]ptically combined means a lamp having a single or two filament light source or two or more separate light sources that operate in different ways, and has its optically functional lens area wholly or partially common to two or more lamp functions."); *see also* EX1067, 5.

24. Optically combined headlamps *must* be able to change direction in order to achieve at least the high beam and low beam functions. And the above diagram shows such directional change for both beams. In the above Figures 5 and 6, H denoting the horizontal line, V denoting the vertical line. This is the angular coordinate system for all automotive lighting light intensity, or candela value, measurements. Numbers listed in the diagram above on the coordinates are the

FMVSS 108 and SAE J1383 (EX1065) required candela values, color blue is for the minimum, and color red is for the maximum allowed. More simply put, the high beam is a narrow-spread beam that is aimed for far-distance illumination (preferably 140 meters or farther). To be sure, in regulatory terms, FMVSS 108 requires at 12-degree left and right measured at H (0-degree) for 1500 cd and 2.5-degree down for 1000 cd min, and HV for 40000 cd min. 49 C.F.R. § 571.108. Low beam has wider spread. FMVSS 108 requires at 20-degree left and right measured at 4-degree down for 300 cd min. 49 C.F.R. § 571.108. Dr. Turk acknowledged that he did not know how intensity would be measured for automotive headlamps when asked during the related '029 patent deposition. EX1054, 103:13-20. "Maximum intensity" as a term used in the art (EX1005, 6:11-12) is understood by a POSA as the relevant regulation and standard allowed the highest luminous flux or candela (cd) value, at a specific (angular) testing point, line, or zone for a given lamp (low beam, high beam, fog lam, etc.) beam pattern. There is no universal maximum intensity for any beam pattern. Often, the regulation and standard do not have the requirements for the maximum intensity such as the high beam expect at one test point (HV), and one line (4D, 4L to 4R). As such, the maximum intensity can be depending on different applications for desired road illumination used in AFS and ADB.

25. Based in my work in the field, a POSA would also have understood that OEMs often add further specifications for wider low beam spread measured up to 40-degree left and right with certain candela values. I previously worked for four years on automotive lighting including technology development, product design, testing, and compliance for standards and regulations for General Motors before transitioning to North American Lighting, where I implemented adaptive front-lighting system and other lighting technologies for fourteen years. EX1003, ¶¶11-12. I then worked at OSRAM Opto-Semiconductors on automotive lighting for an additional eight years of industry experience with continuation in automotive and other lighting applications. EX1003, ¶13. In my experience, a POSA would have appreciated that for commercial applications in the U.S., high beam only has one maximum intensity point at HV, and would have appreciated that there is no maximum intensity requirement for other angles. As above, this shows that a POSA would have readily understood that such beam pattern *always includes direction*. Again, unsurprisingly, Dr. Turk acknowledged that he would not know which standards a POSA would look to, e.g., to know the standard methodology for measuring high-beam light output (headlamp with high beam and low beam functions is a highly regulated and consistently enforced automotive lighting device in the U.S. and rest of the world). EX1054, 154:20-155:15.

26. Dr. Turk also seems unfamiliar with other basic concepts that I would expect a POSA to readily understand. For example, he does not know if a LED die is a directional light source—which is a basic level of understanding I would expect from any POSA:

Q. Is an LED die a directional source?

A. Excuse me, you said an "LED die"?

Q. Correct, d-i-e.

A. I hadn't really thought about that so I'm not sure how to -- how specific I can answer that at the moment.

EX1053, 32:3-13, 32:24-33:1.

27. Dr. Turk also seems unfamiliar with how a headlamp system would adapt characteristics of the light beam according to different driving conditions. For example, when asked: "Would a person skilled in the art want to adapt the light intensity of the headlamp on an illuminated urban road differently from an unilluminated country road," Dr. Turk replied, "[i]n general, *I don't know what a person of ordinary skill in the art wants to do*." EX1052, 126:6-15. Dr. Turk also acknowledged that he does not know whether a person of ordinary skill in the art would want to switch operation of headlamps in response to different driving situations, such as turning on windshield wipers for raining conditions. EX1052, 108:2-11.

28. These incorrect statements and misunderstandings in Dr. Turk's declarations and depositions, along with the dearth of experience in the field reflected on his CV, convince me that he is not a POSA, and does not understand fundamentals in automotive lighting and lighting control with no knowledge of basic concepts, lighting principles, lighting metrics and measurements, lighting regulations and standards, which a POSA would have. The examples include the basic terms of "intensity," "brightness," high beam, low beam, and other automotive lighting devices and their well-defined functions and requirements, how those lighting devices are optically combined, and other basic and commonly used terms that a POSA would readily understand. He does not understand how a POSA would go about measuring such lighting quantities (e.g., in development or under certain regulations, EX1054, 103:22-108:14, 150:23-156:3), or what a POSA would have found obvious to combine with respect to the applied references discussed here and in my First Declaration, EX1003.

2. Dr. Turk has shown he is not familiar at all with basic developments in controllable headlamps, including, for example, the major EUREKA project and technical events, etc.

29. I was shocked that Dr. Turk was not aware of the EUREKA project, one of the most well-known, major projects that involved internationally joint research that included developing adaptive front lighting systems (AFS) and legislative proposals related to automotive lighting and lighting control

standardization. EX1054, 149:17-18 ("Q: Doctor, are you familiar with the EUREKA Project? A: It does not ring a bell at the moment."). Indeed, I specifically commented on the Eureka Project in my First Declaration: "The EUREKA Project was a well-known consortium that a POSA would have been aware of." EX1003, ¶49. He also acknowledged that he is not familiar with the Progress in Automobile Lighting conference (PAL), which revolves around developments in automotive lighting and lighting control, in the technological, design, testing, and regulation aspects. EX1054, 149:19-23 ("Q: Are you familiar with the Progress in Automobile Lighting Conference, also referred to as PAL?....A: I don't recall that conference at the moment, no.").

30. A POSA certainly would have been familiar with the EUREKA project and technical events such as PAL, especially with reference to adaptive front lighting systems. Several of the background references in my First Declaration are articles from conference proceedings of PAL, a well-known, well-attended, bi-annual international conference. Members of the companies and organizations that participated in the EUREKA Project often attended the PAL Symposium and contributed technical papers. I personally attended the PAL Symposium in both 1995 and 1997, and my technical papers were published in both proceedings. This major project and conference/proceedings would be readily

recalled by a POSA, and Dr. Turk's lack of knowledge of even their existence shows he is not a POSA.

31. Relatedly, while the EUREKA project and PAL both show that the adaptive front lighting systems were well known many years ahead of the '503 patent's earliest possible priority date.

3. Dr. Turk acknowledges my expertise when discussing considerations of a POSA—and even though he cites several papers I co-authored, he ignores their substance and does not appreciate what a POSA would actually have understood.

32. As explained above, Dr. Turk also incorrectly states that "beam pattern" is "related to brightness and darkness of illumination within the shape." EX1054, 43:2-4. And this is in direct conflict with the Second Turk Declaration's paragraph 26 here, where he quotes *from an article that I co-authored*, explaining that "[a]ny automotive headlamp beam pattern, either high-beam or low-beam, is a light luminous intensity (candela) angular distribution." EX2010, 237. This misunderstanding and conflicting testimony indicates to me that he does not understand the art – his misunderstanding during deposition should have at least been consistent with documents he himself quotes and relies on. Such an inconsistency and demonstrated lack of understanding calls into question, in my mind, whether he actually read my co-authored articles in order to attempt to form an opinion on them.

33. Further, in the Second Turk Declaration, Dr. Turk even acknowledges *my* expertise and qualifications to opine on what a POSA would have understood in vehicle forward lighting, including automotive lighting and lighting control. EX2006, ¶¶30-38, quoting various articles that I co-authored, for example, EX2010, EX2012, EX2013, and EX2015. He also acknowledged this that I am expert in vehicle forward lighting and LED headlamps in the related '029 patent deposition. EX1054, 58:9-19, 59:16-19.

34. I have reviewed the other articles Dr. Turk cites that I co-authored, along with others, and *none* support his arguments that a POSA would have found challenges in automotive lighting related to LEDs, regulations, design tradeoffs, hardware, optical systems, heat management, packaging, or cost to suggest any of the claims of the '503 patent are patentable. EX2006, ¶¶29-34, 36-38. Rather, his disjointed citations indicate to me that he does not understand the subject matter of those articles, and further indicates to me that he is unaware that the '503 patent does not purport to *solve any* such issues.

35. While LED lighting had progress to make before wide commercial adoption, and certain regulatory restrictions limited commercial implementation of, for example, LED headlamps, AFS, and ADB systems, it is *not* the case that such developments are purported to be solved by the '503 patent or its claims. Nor would such progress required to be commercially viable be a deterrent for a POSA

to seek to improve known systems via modification or adoption of other known systems.

36. Rather, I gave several examples of the known state of the art in my First Declaration. *See*, *e.g.*, EX1003, ¶55. Specifically, I explained citing extensive background literature, that a POSA would have understood that:

> Further, arrays of independently controlled narrow-beam directional light sources, for example, light emitting diode (LED) arrays, were developed with sufficient illuminance, directionality, and dynamic control as an alternative to traditional incandescent and gas discharge bulbs to provide adaptive light patterns and real-time feedback. EX1005, 1:5-3:44, 4:9-59; EX1010, 1:10-26, 9:18-26, 20:29-32; EX1015, 6-18, 21; EX1009, 16:6-25, 20:15-33.

EX1003, ¶55.

37. With respect to AFS, I gave several examples of the known state of the art in my First Declaration with respect to *directional* control. For example, I stated "[a]daptive lighting commonly used multiple directional light sources (e.g., multiple directional beams, such as light modules or beam contributors) to produce an adaptive light pattern (angular light intensity distribution) by varying illumination characteristics including beam intensity, beam shape, beam color, beam direction around curved roads, and glare reduction." EX1003, ¶52.

38. Also with respect to AFS, I gave several examples of the known state of the art in my First Declaration with respect to *glare* control. *See*, *e.g.*, EX1003,

¶¶45-50. For brevity, I reproduce only the text of paragraph 55 of my First Declaration, which summarizes my conclusions:

> By 2000, adaptive headlamp systems with multiple directional light beams were developed with various means of sensors to detect surroundings while driving and resulted in glare reduction for oncoming and preceding vehicle drivers. EX1005, 1:5-3:44, 4:9-59; EX1010, 1:10-26, 9:18-26, 20:29-32; *see also* EX1015, 6-18, 21; EX1016, 1-19 ("[A]ll GRE experts acknowledge the experience with the new technology of front lighting, designed to improve the illumination and to adapt it to various driving situations, whilst reducing glare."); EX1009, 6:4-7; 16:6-25, 20:15-33 ("According to an aspect of some embodiments of the present invention, the pattern recognition application identifies oncoming vehicles and automatically adjusts illumination provided by the luxels to prevent glare from light provided by the luxels from blinding a driver of the oncoming vehicle."). Further, arrays of independently controlled narrow-beam directional light sources, for example, light-emitting diode (LED) arrays, were developed with sufficient illuminance, directionality, and dynamic control as an alternative to traditional incandescent and gas discharge bulbs to provide adaptive light patterns and real-time feedback. EX1005, 1:5-3:44, 4:9-59; EX1010, 1:10-26, 9:18-26, 20:29-32; EX1015, 6-18, 21; EX1009, 16:6-25, 20:15-33.

EX1003, ¶55.

39. A POSA would have been familiar with these developments and state of the art, and Dr. Turk's lack of understanding of automotive lighting and lighting control makes clear that he is not a POSA, and never has been.

40. Moreover, because Dr. Turk ignores this well-known information that a POSA would have appreciated—even after I provided a detailed discussion of what a POSA would have appreciated with regard to automotive lighting and lighting control—his entire analysis presented in each of his declarations is flawed such that he *could not* have taken into account the knowledge of a POSA in his observations.

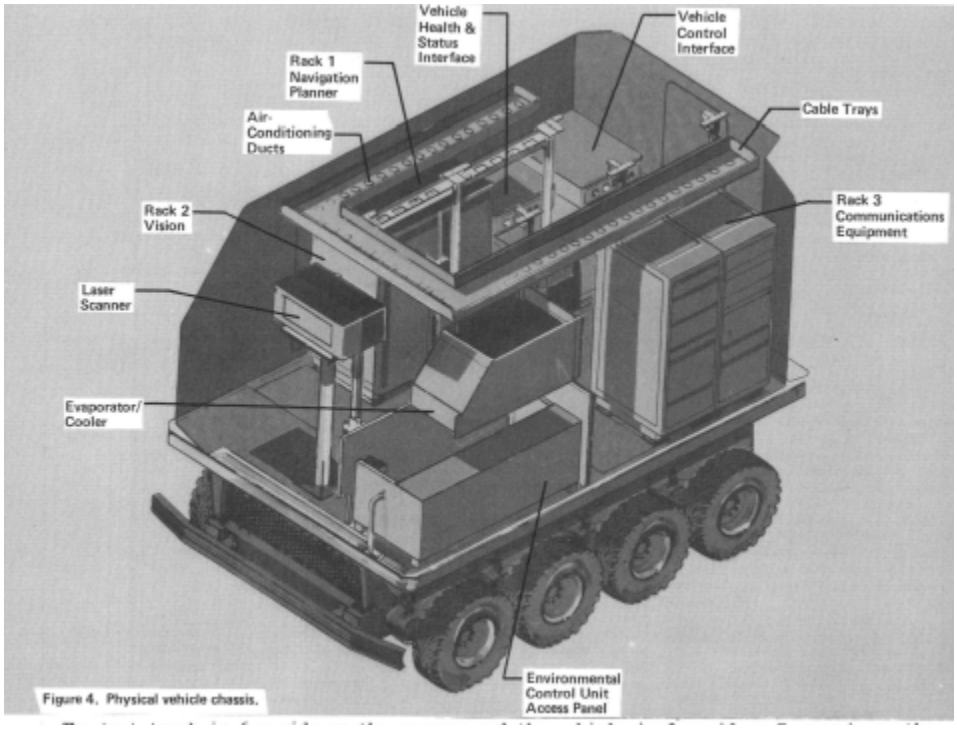
B. I am convinced that Dr. Turk's inadequate, tangential experience related to self-driving systems is not adequately relevant to the subject technology to qualify him as a POSA.

41. When asked about his experience as a POSA in the related '029 patent deposition, I note that Dr. Turk pointed to just one experience he found "a bit" relevant to his experience as an alleged POSA, specifically, work related to autonomous vehicles at Martin Marietta Denver Aerospace. EX1054, 53:4-25. After reviewing that experience and public records documenting that project related to autonomous vehicles, I confirm that this experience is not adequate to establish that Dr. Turk is a POSA.

42. This project, known as the "Autonomous Land Vehicle" or "ALV" project, utilized standard testbeds with a known vehicle chassis that included the headlamps of those vehicles. EX1063, 10-12 (Section titled "Demonstration Plan," noting that General Dynamics and/or FMC provided the chasses, *which has no*

relevance to the art of passenger vehicle headlamp systems disclosed in the '551 patent).

43. Indeed, a paper co-authored by Dr. Turk shows a figure of the project installed over "a drive chassis supplied by Standard Manufacturing," and notes that "[t]his physical platform is considered to be sufficient to support the electronics for all projected demonstrations and experiments." EX1064, 338.



EX1064, FIG. 4.

44. The same paper co-authored by Dr. Turk, includes a figure of the "Long-range ALV system architecture":

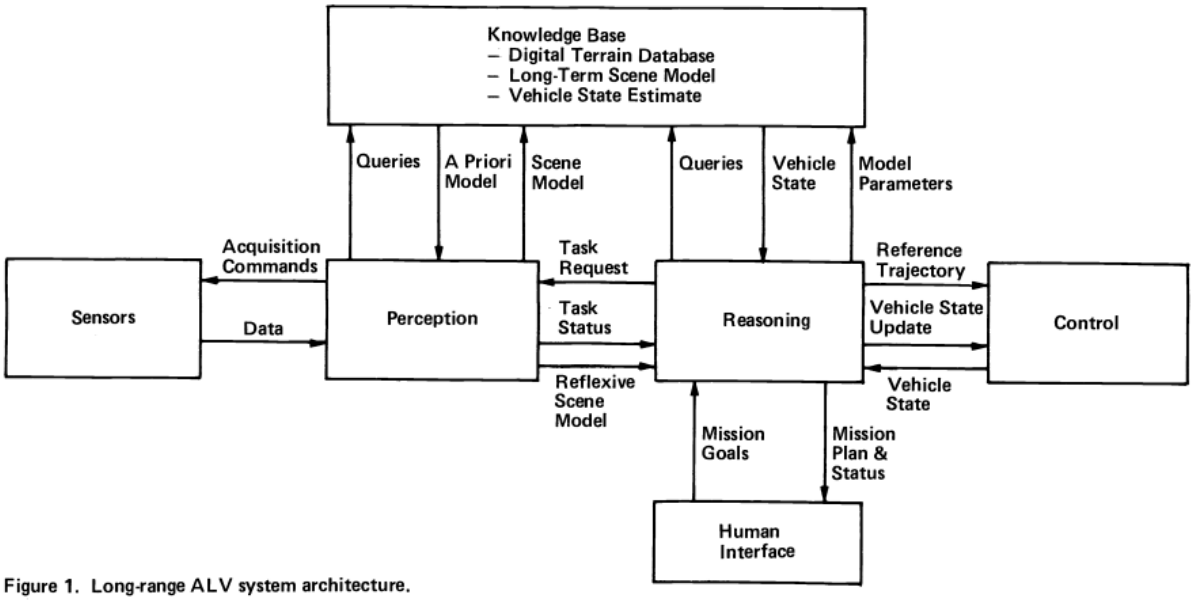


Figure 1. Long-range ALV system architecture.

EX1064, FIG. 1.

45. The system architecture of what Dr. Turk considers to be his most relevant experience with automotive lighting and lighting control does not even include any mention of either automotive lighting or lighting control. EX1064. The system architecture of the ALV makes no mention of any lighting parameters, characteristics, inputs, outputs, considerations, etc. There is no discussion of glare reduction or adapting to road curvatures.

46. Last, to be clear, I understand that in developing self-driving systems, lighting may be included, for example, as developed by the makers of the *standard chassis*. However, such experience is limited and tangential at best, and bears no resemblance to work an actual POSA would be involved in under the umbrella of automotive lighting, much less adaptive headlamps using LEDs with lighting control such as the subject of the ’503 patent.

47. Assuming the ALV had headlamps, they were part of a standard, pre-manufactured chassis or subsystems that did not require any additional work or design, or any automotive lighting and lighting control that is the subject of the '503 patent. This further indicates to me that Dr. Turk has no relevant experience in the field of automotive lighting or lighting control, and he does not qualify as a POSA under his accepted definition.

48. Dr. Turk acknowledges that he has no experience in the field of automotive lighting, lighting control, general lighting, light measurements, and lighting device development, design, process, testing, standard and regulation compliance. He never worked for a vehicle headlamp company, has never worked for an LED (or any other light source) company, has never worked for a general lighting company, has not designed a vehicle forward lighting system, has no patents for any vehicle forward lighting, has never won any awards for vehicle forward lighting, and has no papers on vehicle forward lighting. EX1054, 52:18-53:1, 54:24-56:12. Without any such experience, I fail to see how Dr. Turk can hold himself out as a POSA under his accepted definition, much less an expert qualified to opine on what a POSA would have understood. Dr. Turk has not participated in any lighting professional associations' activities, is not a member of the Society of Automotive Engineers (SAE International), International Society for Optical Engineering (SPIE), or Illuminating Engineering Society (IES), EX1054,

57:9-17 (a few major lighting professional organizations), which is further indicative of a lack of any focus or even awareness on automotive lighting and lighting control—his lack of participation in SAE International, in particular, even suggests a lack of focus on automotive engineering in general.

49. As I understand it from his CV, declarations, and deposition testimony, Dr. Turk's *industry experience* relates to "computer vision methods for recognizing human faces, gestures, and activity." EX2006, ¶12 (defining Dr. Turk's "industry experience"). Even if Dr. Turk is an expert in "computer vision,… concerning automatic face recognition," EX2001, ¶¶7, 10, 12, 15-16 (detailing Dr. Turk's experience with facial recognition technologies); EX2006, ¶¶9-10, 12, 14, 17-20 (same), EX1054, 22:15-17, 22-24 (same), this is *not a case about automatic facial recognition*. The closest experience in Dr. Turk's CV appears to be his work at Martin Marietta Denver Aerospace, working on computer "vision for autonomous vehicle *navigation*," not automotive lighting and lighting control or even lighting technology. EX2002, 5-6. The patent claims at issue concern automotive lighting and lighting control, and Dr. Turk has not indicated that he has any requisite "industry experience in the area of automotive lighting and lighting-control systems" required to be a POSA. EX1003, ¶42.

V. DR. TURK DOES NOT UNDERSTAND THE FUNCTIONS AND BENEFITS OF A SPATIAL LIGHT MODULATOR.

A. Spatial light modulators were well-known structures and provided additional functionality to LED-based headlamps.

50. I reviewed Dr. Turk's brief section on spatial light modulators ("SLMs"). EX2006, ¶35. Dr. Turk seems to misunderstand basic aspects of the use of SLMs in headlamps that would be well known to any POSA, specifically the use of SLMs in controlling beam pattern directionality.

51. To start, Dr. Turk's conclusion that a POSA would never combine an SLM and LEDs is based on a misunderstanding of how LEDs function. EX2006, ¶38. An LED by itself is usually used in the form of an LED array or LED module is a light source that emits a light beam with a *fixed* light angular distribution when a secondary optic is added onto an LED die or dies to form into an LED package. Such an LED light source typically has a light spread angle of tenths of degrees, e.g., as the '503 patent acknowledges, "[p]resent day LEDs come in very narrow aimings such as two half angle 8 degrees which may not be narrow enough (a 10 meter spread for 150 meters down the road which may be sufficiently aimed to the right) but with need, smaller angles are also feasible." EX1001, 52:55-63. Without the secondary optics (e.g., lens), an LED die has the Lambertian light distribution (uniform angular distribution in a hemisphere). EX1062, 1:51-61. In the lighting industry, when referring to LED light sources, the term "secondary optics" is

commonly known as the optical element (e.g., a lens) that is assembled with a LED die and other electrical and mechanical elements into an LED package. An LED array or LED module usually consists of multiple LED packages. EX1057, 11:49-53. Secondary optics on the LED package provide a fixed but not very narrow (tens of degrees) spread for light angular distribution. The LED emission of light can be varied by controlling the input electrical power (operating current) provided to the LED, but absent some other mechanism, the LED's light angular distribution cannot be changed. EX1057, 10:25-29. The brightness of the light in that distribution may be changed, however, by controlling the input power used by the light for illumination. This means that if a headlamp was only formed from LEDs, it could not control the directionality of its light beam outside of the fixed constraints of the directions of the LEDs in the array. For this reason, a POSA would have known to include mechanisms to alter the light directionality, as confirmed by the prior art's use of modulators and/or physically moving the light source.

52. The primary ways for an LED light source to alter its angular distribution is to either physically move the LED to change the direction the LED points or aims or to use additional, known optics to control the light distribution from the fixed LED. For example, physically moving the LED would be analogous to a light fixture mounted to a ceiling by a movable structure (like a flexible arm or

hinge). Indeed, the '503 patent discloses that "by the alteration of fixture geometry, moving structures or arms on which the light sources are mounted or by changing the LEDs' refractor or reflector geometry, the direction of the light emanating from groups or even individual light sources is modified so as to generate an overall site specific light distribution pattern." EX1001, 59:22-27. The light fixture can be moved to point at different parts of the room or illuminated object, thus changing the angular distribution of the light. This strategy is similar to how both Kobayashi and Gotou function to control their light beam patterns to account for road curvature. EX1008, 6:4-39 (changing light directionality by either swiveling the entire lamp mechanism or moving specific optical control elements such as reflectors); EX1012, 3:31-41, FIG. 2 (pivoting lamp unit via a rotary a swing mechanism). As an alternative to physically moving LEDs, changes in angular distribution can also be accomplished by using additional optics, for example, optical control elements like lenses and reflectors that are typically separate from the light source (e.g., LED package, LED array, or LED module consisting of LED die(s) with secondary optics). To further extend my analogy, this would be like holding a hand mirror up to the fixed ceiling light fixture and moving the hand mirror to reflect light to different parts of the room. Kobayashi discloses this well-known strategy to adapt to road curvature changes. EX1008, 11:5-14 (discussing

altering the spatial arrangement of optical elements such as reflectors to control beam direction).

53. SLMs fall into this category of additional optics. They can be used to shape or change the directionality of a light beam, including light produced by LEDs. EX1059, 2:56-63, 6:19-30, 2:65-3:1, Abstract (disclosing a spatial light modulator used to control light from an LED array); EX1058, 3:62-4:24 (disclosing using a spatial light modulator to control light emitted from LEDs). Indeed, Dr. Turk cites one type of spatial light modulator, a "digital mirror device" or DMD, which uses an array of micromirrors to control directionality. EX2006, ¶35 (citing EX2022); EX2022, 2. Exhibit 2022 explains that "[t]he DMD pixel is an opto-mechanical element in that these two positions [of the micromirror] determine the direction that light is deflected." EX2022, 2. And controlling angle, or directionality, is a known function of SLMs. EX1056, 19 ("SLMs may reflect or transmit the readout light, and modulate its intensity, phase, polarization, or *angle* depending on the light modulating medium."). Karlsson discloses other examples of SLMs, including "Suspended Particle Devices," "Liquid Crystal Devices," and "Quantum Wells." EX1010, 5:11-15. Similarly, Beam discloses spatial light modulator examples including "digital mirror devices, liquid crystal devices, and grating light valves." EX1005, 8:4-12. Thus, any POSA would understand that if directional control of LEDs is desired, an SLM is one way to achieve that

directional control. This provides the benefit of having directional control over the light emitted from the LEDs, instead of only having control of the brightness of that light.

B. Beam's system includes both an LED array and a spatial light modulator, contrary to Dr. Turk's demonstrably false assertions.

54. Turning to Beam specifically, Dr. Turk opines that Beam's LED array renders its "modulator….superfluous." EX2006, ¶67. Moreover, Dr. Turk takes the untenable position that "a POSA, in view of the redundant functionality there is no reason to sue an SLM in combination with individually controllable light sources such as LEDs for adaptive headlamp applications." EX2006, ¶38. But this is demonstrably false, as exemplified by Beam's claim 4. EX1005, 8:4-12; EX1003, ¶116. Indeed, I note that when confronted during his deposition for the related '029 patent, Dr. Turk acknowledged that, for example, Beam's claim 4 does, in fact, expressly disclose a system that includes both an array of LEDs and a spatial light modulator. EX1054, 89:21-90:9, 90:17-91:8.

55. An SLM with an LED array is not superfluous and was known in the art. EX1059, 2:56-63, 6:19-30, 2:65-3:1, Abstract; EX1058, 3:62-4:24. Indeed, Beam's disclosure includes a beam pattern comprising many—on the order of 300,000—individual, narrow angle microbeams, which may come from LED sources. EX1005, 4:41-44; EX1003, ¶73. Of course, Dr. Turk acknowledged that Beam would not include 300,000 LEDs, rather, a spatial light modulator would be

included. EX1054, 101:4-102:15. Beam's microbeams are "diverted or attenuated" (EX1005, 5:65-66) which a POSA would understand means, for example changed direction or dimmed. A POSA would not conflate these concepts as Dr. Turk did during the related '029 patent deposition, where in responding to a question that asked whether his understanding of Beam is that the term "angular position" is the same thing as "attenuation," he responded that "…the angular position of each microbeam is equated to the attenuation of each microbeam." EX1054, 94:21-96:12.

56. Nonetheless, Dr. Turk ultimately acknowledged that each of Beam's microbeams can be directed by Beam's SLM:

> Q. This passage also describes that the microbeams are individually directed, right?
>
> A. Yes.
>
> Q. What is "directed" in this context?
>
> A. I believe this, in this context, it's describing the modulator embodiment and so direction of the microbeams refers to as -- either the mirror positioned to send the light out or the mirror positioned to not send the light out.

EX1054, 100:14-22.

57. Thus, Dr. Turk agrees that Beam's microbeams are directed. Beam discloses that its microbeams can be created by LEDs, and thus the LED microbeams are directed by the SLMs. EX1005, 4:41-44, 8:4-7.

C. Karlsson's system also includes both an LED array and a spatial light modulator, contrary to Dr. Turk's demonstrably false assertions.

58. Similarly, Karlsson includes both a spatial light modulator and LEDs. For example, in Karlsson, Figure 7 (shown below) includes "light source 2 [that] is comprised of a plurality of separate small light sources." EX1010, 14:22-23; EX1003, ¶¶251, 256, 263. And Karlsson discloses that light source 2 can include "Light Emitting Diodes (LEDs)," which a POSA would know are a plurality of separate small light sources. EX1010, 21:13-17. Thus, the light source in Figure 7 is formed from LEDs.

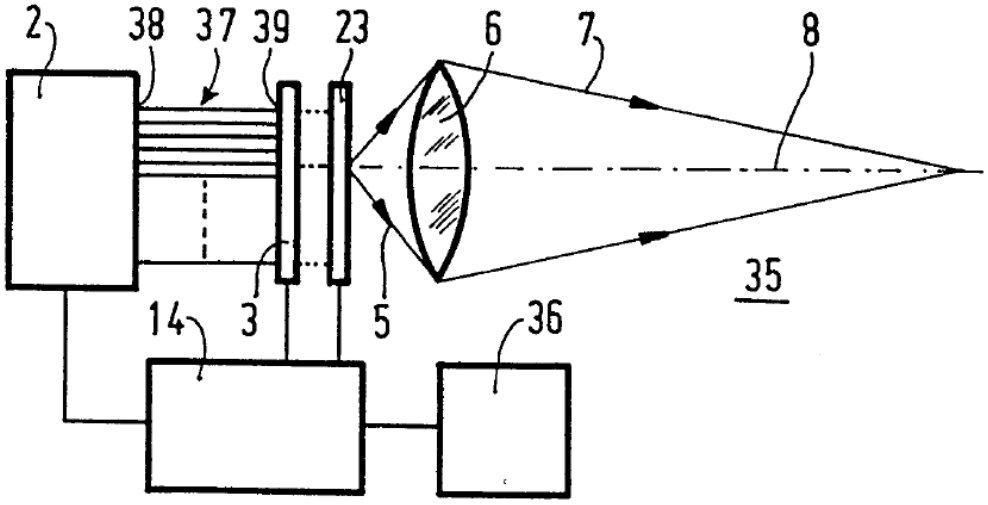


FIG. 7

EX1010, FIG. 7.

59. As shown above, Figure 7 also includes a "light modulator means 3," which is Karlsson's term for an SLM. EX1010, 14:35-36, 5:11-15 (discussing light modulator means as "spatial light modulators"); EX1003, ¶263. Light modulator means 3 is positioned to control the light emitted from light source 2 (e.g., LEDs). Thus, Karlsson's Figure 7 specifically discloses to a POSA both SLMs and LEDs. *See* EX1053, 36:19-21 (Dr. Turk confirming that Figure 7 includes both an SLM and light source); EX1053, 38:15-25 (Dr. Turk agreeing that Karlsson's light source 2 can be LEDs). Karlsson's Figure 3 also includes a light source 2 and light modulator means 3, and therefore is another example of an SLM being used with LEDs. EX1010, 11:7-15, FIG. 3.

60. In summary, the First Turk Declaration, the Second Turk Declaration, and the Turk Depositions all demonstrate his lack of or misunderstanding of the functions and benefits of spatial light modulators (SLMs). Yet Dr. Turk has acknowledged that both prior art references Beam and Karlsson disclose the SLMs. He also acknowledged that Beam's microbeams and Karlsson's spotlight beams can be directed by SLMs.

VI. DR. TURK'S SUBSTANTIVE ARGUMENTS AGAINST BEAM-THOMINET ARE INCORRECT, AT LEAST IN PART BASED ON HIS MISUNDERSTANDING OF THE ART.

61. Dr. Turk's substantive arguments against the Beam-Thominet combination are not correct, and I believe they are based upon his fundamental misunderstandings of the art as I have laid out above.

A. Beam-Thominet discloses at least three directional light sources aimed at different angles, as recited in [20.2].

1. Beam's microbeam sources are "directional light sources."

62. My First Declaration makes clear that Beam's headlights include at least three directional light sources aimed at different angles relative to the vehicle in the form of "an *array* of *individual*, *independently* controllable *microbeam* sources." EX1005, 8:4-17. EX1003, ¶¶146-149. Beam's microbeam sources are controlled individually or grouped to adjust "the intensity, and/or the *angular position*, of one or more narrow-angle *microbeams*." EX1005, Abstract. By controlling the "angular position" of "one or more narrow-angle microbeams,"

Beam's microbeam sources are "directional light sources aimed at different angles." EX1001, 97:59-66.

63. A POSA would have understood that Beam's microbeam sources are "directional light sources" in view of the '503 patent specification. The '503 patent discloses the light source as "light sources modified by optical-control elements to form narrow-beams." EX1001, Abstract. The '503 patent equates "light sources" to "narrow-beams" that are directional and aimed at different angles.

64. Just as the "directional light sources" are described in the '503 patent, Beam discloses the microbeams being "narrow-angle microbeams," (EX1005, Abstract) and individually controlled for their angular position (direction or aiming angle). EX1005, 4:26-59, 5:3-21. My First Declaration explained that Beam discloses two examples of such narrow-angle microbeam sources: lamp 202 and SLM 203 shown in Figure 2, and the array of light sources 401 shown in Figure 4. EX1005, 4:26-59, 5:3-21. EX1003, ¶¶118-119. Because Beam's microbeam sources shown in Figures 2 and 4 each include light emitting elements and a SLM (EX1005, 8:6-9, "microbeam sources selected from the group consisting of light-emitting diodes, … a spatial light modulator."), Beam's microbeam sources generate and control the angular position of thousands of microbeams. EX1003, ¶¶118-120. Thus, a POSA would have understood that Beam's microbeams of Figure 2 and Figure 4 each include at least three directional light sources aimed at

different angles. *See* EX1003, ¶147 ("Each microbeam is a 'source' that combines to form the headlight beam, and the combination of Beam's lamp 202 and SLM 203 and/or array of light sources 401 form many, and at least three directional light sources having different directional (or aimed) angles/aimings.").

65. I understand that the Board disagreed with the analysis in my First Declaration, finding that "microbeams" are the light itself, not a light source. DI, Paper 13, 11. Dr. Turk agreed with the Board's position, asserting that the light source in Figure 2 of Beam is just a single directional lamp and that the LED array 401 shown in Figure 4 of Beam has no ability to provide independent angular portioning. EX2006, ¶¶120-130. Dr. Turk's characterizations of Beam's microbeam sources are technically inaccurate. Both Dr. Turk and the Board did not take into account that "directional light sources," as recited in claims (EX1001, 97:61-66) and as to any light source having directionality, need an optical element to provide light beams aimed at particular angles, as explained below.

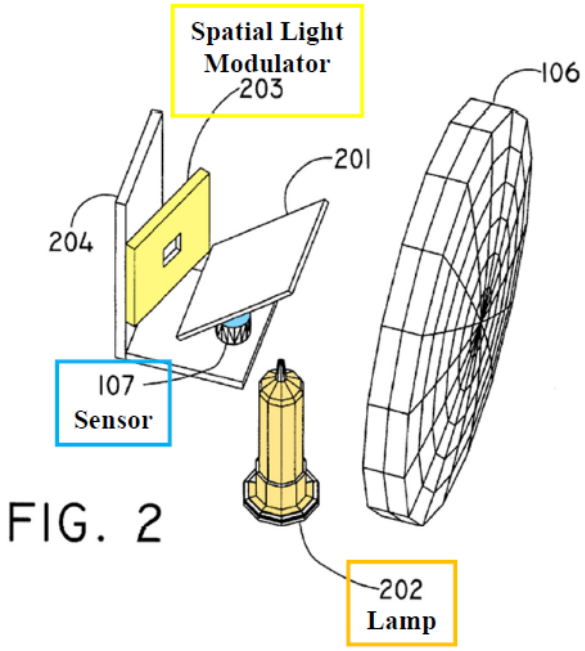


FIG. 2

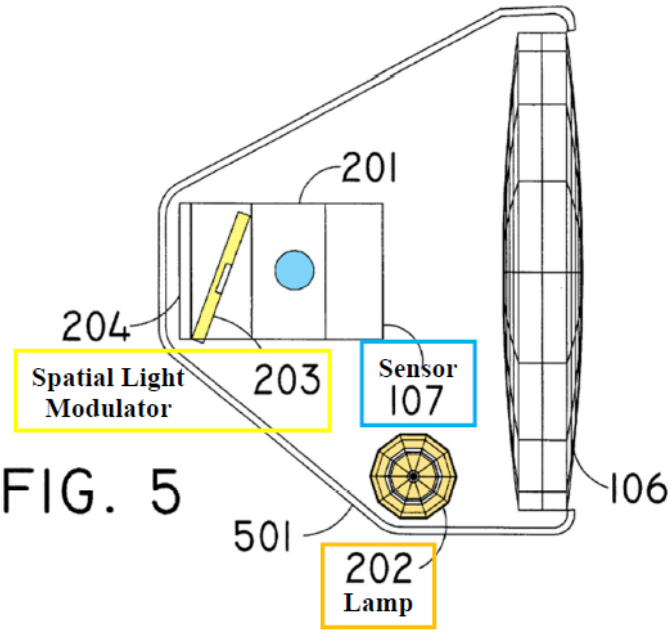


FIG. 5

EX1005, FIGS. 2 and 5 (annotations from EX1003, ¶126).

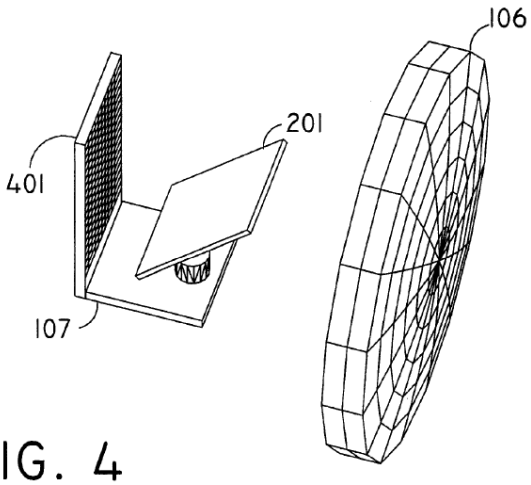


FIG. 4

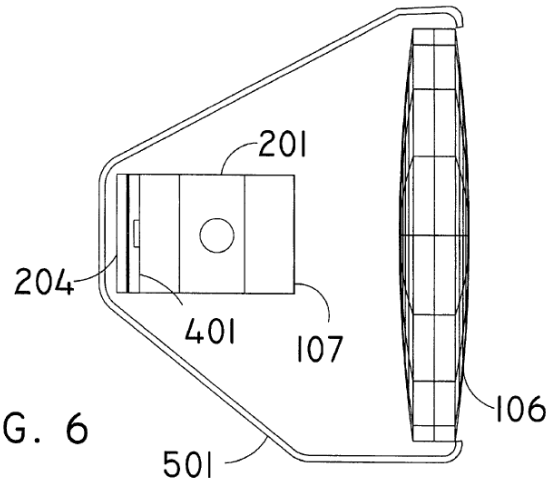


FIG. 6

EX1005, FIGS. 4 and 6.

66. A POSA would have understood that Beam's microbeam sources include both an emitter and an optical element to control the intensity and the angular position of the microbeams. *See* EX1003, ¶70 ("Therefore, in my opinion, a POSA would have understood that 'light sources" includes … *the combination of*

light sources and spatial light modulators, for example, *microbeam sources* and spotlight beam sources.") This is consistent with what is recited in the claims. Claim element [20.2] recites "*directional* light sources." In order to be "directional," a POSA would have understood that the emitter of the light source is combined with an optical element. For example, combining an emitter, such as Beam's lamp or LEDs, with SLM outputs a directed "narrow beam." A POSA would have understood that a light emitter, without an optical element to collect and collimate light, will not be directional. Indeed, for any type of light emitting source, including incandescent filament, high-intensity discharge arc, LED die, etc., without optical control element, the light emission is omnidirectional.

67. A POSA would have understood that Beam's combination of lamp 202 and the individually controllable optical modulators in SLM 203 meets the Board's construction of "light source." In its Institution Decision, the Board construed light source inconsistent with how I applied the term in my First Declaration. DI, 8. The Board construed light source as "any *system* that is capable of receiving an electrical signal and producing light in response to the signal." DI, 8 (citing EX1001, 17:7-10.). As I stated in the above, "any *system* that is capable of receiving an electrical signal and producing light in response to the signal" does not define what '503 patent's disclosed "directional and aimable" light source. Beam's lamp 202 and the plurality of modulators in SLM 203 receive an electrical

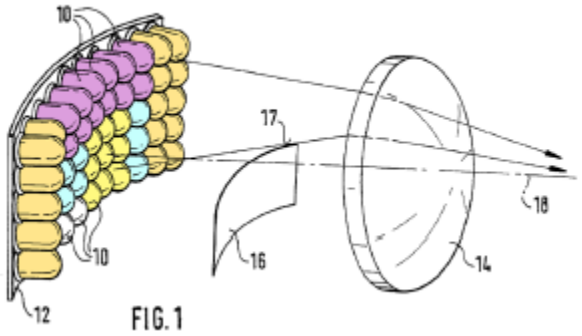
signal from controller 108. EX1015, 4:53-57. In response to receiving a command signal from controller 108, Beam's SLM produces and controls the angular distribution of the microbeams. EX1005, 4:53-57 ("To accomplish this, the spatial locations of the sources are mapped into controller 108 which then commands spatial light modulator 203 in illuminator 109 to either divert the selected microbeams or to attenuate them, depending on the implementation of spatial light modulator 203 chosen.") Thus, Beam's microbeam sources are "directional light sources."

68. Nonetheless, Beam's microbeam sources also meet the Board's definition—lamp/LED-array and SLM—receive an electrical signal from Beam's controller, thereby producing multiple-angled microbeams. DI, Paper, 13, 7-8; EX1005, 4:26-59, 5:28-31, 5:61-65, 8:4-12; 17:10-15; EX1051, ¶[]. Indeed, a POSA would understand that Beam's lamp/LEDs plus SLM are "other such systems" that are "light sources" according to the '503 patent. EX1005, 17:10-15.

2. Thominet's headlights include "at least three directional light sources aimed at different angles."

69. I agree with the Board's finding in the Institution Decision that Thominet's headlight includes a plurality of light sources arranged at different angles, as shown in FIG. 1, reproduced below. DI, Paper 13, 15. My First Declaration explained that Thominet's headlight includes "at least three directional light sources aimed at different angles" in the form of independently controllable

semiconductor light sources 10 arranged on a "concavely curved surface or a stepped surface" of support element 12. EX1006, ¶¶17-18; EX1003, ¶¶150-152. For example, Thominet's region 24 of semiconductor sources 10 arranged in the center of support element 12 correspond to a first aiming, and Thominet's regions 28 near the lateral edges of support element 12 correspond to second and third aimings. EX1006, ¶¶23, 25, FIGS. 1, 2.



EX1006, FIG. 1 (annotated).

70. Dr. Turk does not dispute that Thominet's headlights includes at least three directional light sources aimed at different angles, as recited claim 20.

B. Beam-Thominet's automotive adaptive headlight system uses a processor to determine, within a field-of-view, a first-subsection including a detected vehicle and a second subsection not including a detected vehicle, to reduce glare, as recited in [20.9-20.13]/[59.7].

1. Beam's automotive adaptive headlight system includes a processor determining the "first-subsection" of claim 20.

71. I agree with the Board's finding that Beam's headlight includes a processor that processes sensor data to determine, within a field-of-view, a first-

subsection including a detected vehicle. DI, 20. My First Declaration explained that controller 108 of Beam's headlight system includes a processor 1105 that "uses appropriate algorithms on the incoming data to determine the locations *to be blanked*…outputs *blanking signals*…*commands* the appropriate pixels to be *reduced in intensity*." EX1005, 5:34-36, 5:46-54. Beam further specifies the type of data inputted to the controller is "sensor spatial data (video)." EX1005, 6:14. Beam's processor uses algorithms to "determine whether there are illumination sources (headlights or taillights) present in the headlight's field-of-view" and the detected vehicle's headlights' "location relative to the Adaptive Anti-Blinding headlights beam." EX1005, 6:14-19. Based on this disclosure, Beam recites a method that includes the steps of "detecting the presence of an oncoming or followed vehicle in an area of illumination provided by … the headlights" and "determining the coordinates of said oncoming or followed vehicle." EX1005, 8:18-28. Accordingly, a POSA would have understood that area corresponding to the detected vehicle's headlight in headlight's field-of-view of Beam is the recited "first sub-section" and that Beam's processor determines this first-subsection in the headlights' field-of-view based on sensor spatial data.

72. Dr. Turk contends that Beam's processor does not determine a first subsection, as recited in claim 20, because Beam's processor "lacks any specific way to differentiate between different sources of incoming light." EX2006, ¶163.

Reading into the claim language, Dr. Turk asserts that claim element [20.9] requires the processor to determine the "fact of" the existence of a vehicle. EX2006, 161. Dr. Turk alleges that Beam's system is "devoid of a machine vision system or pattern recognition system for detecting or identifying a vehicle." EX2006, ¶163. Dr. Turk's assertions are incorrect or irrelevant for multiple reasons.

73. First, Dr. Turk's arguments are based on features not recited in the claims, namely the processor being able to differentiate between different types of light sources, such as using pattern recognition system. Claim element [20.9] recites "the processor, in communication with at least the sensors and the control circuitry, configured to: process the sensor data to determine, within a field-of-view, at least a first subsection including a detected vehicle." EX1001, 98:10-14. Based on my review of the claim language, claim element [20.9] is generic to how the processor determines the first subsection—it does not recite any features specifying how the processor uses the sensor data to detect a vehicle.

74. Indeed, in his deposition, Dr. Turk acknowledged that claim 20 does not require any specific way for determining or confirming the presence of a vehicle. When asked "[c]laim 20 does not explicitly recite how a vehicle is detected, is that correct" Dr. Turk confirmed "that is correct." EX1052, 40:2-4. Dr. Turk elaborated, "I don't think there's anything in this claim that specifies how

that vehicle was detected." EX1052, 40:12-13. Dr. Turk further confirmed that "claim 20 does not specify any particular type of sensor data that is required to determine a detected vehicle." EX1052, 40:15-18. Thus, pattern recognition and light differentiation processing—what Dr. Turk relies in an attempt to distinguish claim element [20.9] from Beam—are *not* required by the plain meaning of the claims. EX2006, ¶¶159-163.

75. Second, Beam's process of using a sensor to detect vehicle head lights to determine the position of an oncoming vehicle relative to the headlight is consistent with the vehicle detection methods described in the '503 patent. The '503 patent specification describes "an electronic headlight which provides the driver with the correct aiming, illumination level, and distribution … based on … *detection of approaching headlights*." EX1001, 50: 53-58. The '503 patent specification also describes that "[a]nalysis by a detector or an imaging system of the oncoming vehicle position (*using its headlights* for example) can be used to determine which exact aiming is the maximum allowable for any given traffic situation." EX1001, 52:66-53:2. Put simply, the '503 patent's headlight system determines the presence of the vehicle by using imaging data to detect vehicle headlights—the same approach used by Beam's system, published one more year before the '503 patent's earliest priority date.

76. While the '503 patent specification does describe using a pattern recognition system to determine "what is a sign," for example, (EX1001, 53:3-6), the '503 patent specification *does not* describes using a pattern recognition system to detect the presence of a vehicle, as purported by Dr. Turk. EX2006, ¶163 ("pattern recognition system for detecting or identifying a vehicle.") Thus, the '503 patent disclosure contradicts Dr. Turk's assertion that so-called "pattern recognition" is needed to detect the presence of a vehicle.

77. Third, a POSA would have understood that Beam's system distinguishes between light sources when determining the presence of a vehicle based at least in part on the detected vehicle's headlights. Beam's system determines a location of the other traffic (via headlights or taillights) using the coordinate-specific information (the video data from the camera). EX1005, 4:29-30, 6:11-15. In Beam, "[t]he spatial scene data from sensor 107 is thresholded to eliminate weak signals and becomes the input to a processor 1105." EX1005, 5:34-36. This filtering technique described in Beam means that lights detected by the sensor are separated into two classes: those that reflect or emit light above the threshold, and those that do not reflect or emit sufficient light. EX1003, ¶184. In doing so, Beam's controller distinguishes between stronger light sources, such as vehicle headlights, and ambient light sources, such as light reflected from street

signs. EX1003, ¶184. Thus, Beam's headlight controller even meets Dr. Turk's unsupported claim requirements.

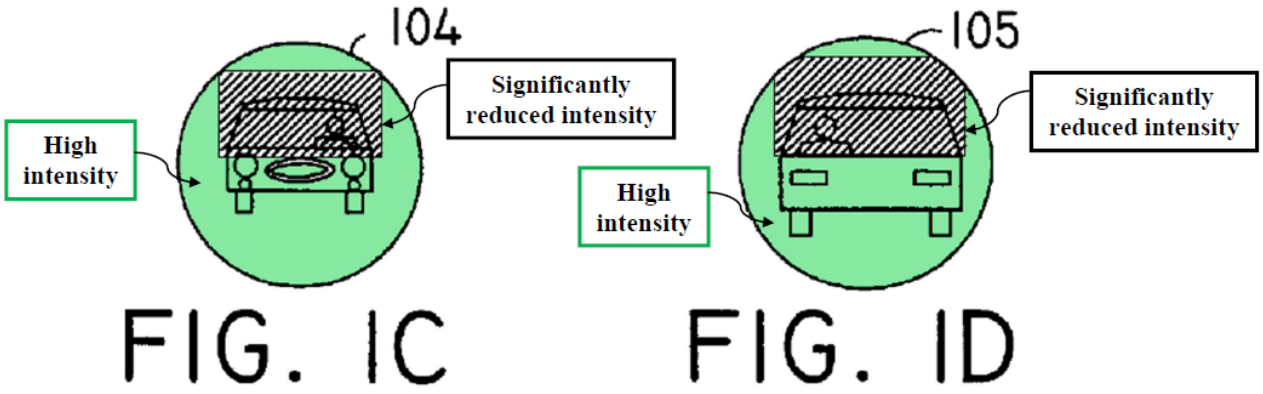
2. Beam's automotive adaptive headlight system includes a processor determining the "second-subsection" of claim 20.

78. Claim 20 recites a "second subsection not including the detected vehicle," without further specifying the boundary of the second subsection with respect to the first subsection of the field of view. EX1001, 98:10-14. A POSA would have understood from the plain language of claim 20 that the "second subsection" does not correspond to the remaining area of the field of view outside of the "first subsection."

79. My First Declaration showed that Beam's headlight includes a processor that determines a second subsection not including a detected vehicle by detecting areas that "do not dazzle the drivers ahead" and "provide intense forward illumination" in those areas that would not dazzle the drivers. EX1005, 3:20-24, 1:15-18; EX1003, ¶186.

80. Dr. Turk conflates this unclaimed feature—second subsection corresponds to the remainder of the field-of-view—with the plain language of claim 20. EX2006, ¶¶173-174. Dr. Turk contends that my First Declaration failed to show a headlight processor determining a second subsection not including a vehicle based on my annotated versions of Figures 1C and 1D of Beam, reproduced below. EX2006, ¶¶173-174. Dr. Turk mischaracterizes (presumably

through lack of understanding) my annotated versions of Beam's Figures 1C and 1D by equating the remainder of the field of the view outside of the "reduced intensity" section to the recited "second subsection." EX2006, ¶174. My annotated Figures 1C-1D of Beam, however, show areas outside of the "reduced intensity" subsection (the first subsection) that do not include the vehicle.



EX1005, FIGS. 1C and 1D (annotations from EX1003, ¶186).

81. Dr. Turk mischaracterizes my annotated versions of Beam's FIG. 1C and 1D and I believe he does not understand them. In view of Beam's disclosure and the analysis in my First Declaration, a POSA would have understood that Beam does determine a second subsection *not* including a detected vehicle that meets the claim language. EX1003, 186; EX1005, 3:20-24, 2:59-3:3, 6:40-44.

82. There is an area in Beam's Figures 1C and 1D that does not include a vehicle, as shown below in annotated version of Figures 1C and 1D.

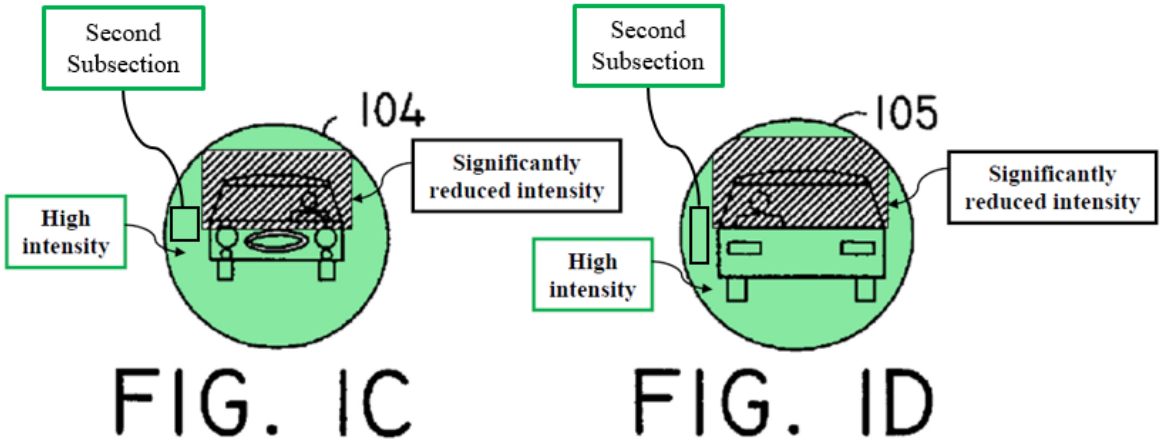


FIG. 1C FIG. 1D

EX1005, FIGS. 1C and 1D (annotated)

83. My application of Beam to the "second-subsection" is directly supported by—and directly reads on—the claim language. As I explained above, claim element [20.10] does not place any limitations regarding the extent of the second sub-section within the field-of-view. This means that any particular area outside the vehicle (driver's portion) may correspond to the second-subsection. Thus, my annotated version of Beam's FIG. 1C and 1D, shows that Beam's second sub-section does not include a detected vehicle.

C. A POSA would have been motivated to combine Thominet's curved substrate with Beam's LED array.

84. As explained in my First Declaration, a POSA would have been motivated to substitute a curved LED substrate, as taught in Thominet, for Beam's flat LED substrate, *at least because* the light sources would be physically aimed at different angles, thereby improving optical performance of the headlight system.

EX1003, ¶¶135-141, 164-170; EX1005, 3:8-14, 3:37-44, 5:33-54, 7:1-13; EX1006, ¶¶17-18, 21, 23-26.

85. Dr. Turk contends that my First Declaration fails to explain why a POSA would have been motivated to combine Thominet's curved substrate with Beam's headlights when Beam's flat substrate already could have achieved the same segment control functionality with just software modification. EX2006, ¶¶142-147. It is not clear to me whether Dr. Turk read any of the paragraphs ¶¶135-141 and ¶¶164-170 of my First Declaration addressing exactly this issue. Nonetheless, a POSA would have been motivated to substitute a curved LED substrate for a flat LED substrate—as laid out in paragraphs ¶¶135-141 and ¶¶164-170 in my First Declaration. Furthermore, a POSA would not have been discouraged from implementing Thominet's curved substrate with an anti-glare headlight system, such as Beam's system.

86. Indeed, rearranging Beam's LEDs on a curved surface, as taught in Thominet, would have yielded the predictable result of providing different spatial distributions for different driving situations. EX1003, ¶¶138. In doing so, Beam-Thominet's headlight systems would "improve[e] visibility and thereby safety." EX1003, ¶¶135-141, 164-170. In Thominet's disclosure, the LEDs are "LED packages" that include optical elements as the secondary optics (lens), which have the equivalent function of the SLM (directional, aimable). To modify Beam's

hardware, a POSA would simply need to arrange Beam's light sources 401 on a curved surface, as in Thominet. This combination is rather simple for a POSA.

87. In response to Dr. Turk's unsupported argument (EX2006, ¶¶142-147, 206), a POSA seeking to improve driver visibility by modifying headlights—as explained in my first declaration—would have readily known that curved substrates enhance the headlight's optical performance. Specifically, a POSA would have understood that using angular-sectional beam contributors, such Thominet's curved LED arrangement, simplifies the optical element design for headlights by reducing aberration, thereby improving optical performance. EX1003, ¶135. Thus, a POSA would have preferred using a form of a curved light source substrate over a flat form in optical design for a vehicle headlight. As I explained in my First Declaration, therefore, this is a rather simple hardware combination. EX1003, ¶¶139-141.

D. A POSA would have been motivated to combine Thominet's multiple directional beam segments with Beam's adaptive headlight system with a reasonable expectation of success.

88. My First Declaration makes clear that a POSA would have been motivated to combine Thominet's multiple directional beam segment technique with Beam to add different functions "for different driving situations beyond reducing glare for drives, thereby improving safety." EX1003, ¶131, *see also* ¶¶123-134, 164-170. In doing so, Beam-Thominet's headlight system would have

been "more direct, or active, or specifically aimed for different functions" such that Beam-Thominet's adaptive headlight would actively direct a light beam to where illumination is desired for a driver. EX1003, ¶128.

89. Dr. Turk opines that a POSA would not have been motivated to combine the teachings of Thominet's multiple direction beam region technique with Beam. EX2006, ¶¶133-136, 148-158. First, Dr. Turk asserts that Beam's conflicts with Thominet's control strategy. EX2006, ¶¶153-158. Second, Dr. Turk asserts that combining Thominet's clustered regions control with Beam's LED array shown in Figure 4 would compromise Beam's modified headlight the ability to deliver forward illumination. EX2006, ¶¶148-152. Third, Dr. Turk asserts that dissimilarities between Beam's lamp/LED/SLM system shown in Figure 2 and Thominet's semiconductor system would discourage a POSA from combining their teachings. EX2006, ¶¶133-136. All of Dr. Turk's assertions are incorrect, and are based on his fundamental lack of knowledge of what a POSA would have understood.

1. Beam's and Thominet's headlight control systems are fully compatible.

90. Beam does not suggest to a POSA that its AABH system *cannot increase light in a direction* by emitting a "beam [that] is at full intensity except in the areas that would dazzle a driver ahead." EX1005, 4:57-59. However, Dr. Turk incorrectly characterizes Beam this way with his assertion that "there is no light

left to place or move" in Beam's system. EX2006, ¶155. Dr. Turk's argument is premised on a misunderstanding of what "intensity" means in the art. EX2006, ¶155.

91. As I explained above with reference to Dr. Turk's lack of POSA qualifications, Dr. Turk appears to not understand what the term "intensity" means in the context of vehicle headlights. It is not, contrary to Dr. Turk's misunderstanding, similar to or synonymous with "brightness," which is a human perception measurement. *See* EX1054, 62:18-25. Dr. Turk opines that the term "intensity" in the context of the related '029 patent should be interpreted as "what intuitively we think of as brightness." EX1054, 84:3-6. Dr. Turk's arguments here in the '503 patent proceedings indicate this same misunderstanding in conflating "intensity" with "brightness." EX2006, ¶¶61-69, 153-158.

92. Beam *controls intensity, including angular position,* to a maximum desired in a given direction, and does not default (using a colloquialism) "full blast" everywhere at all times as purported Dr. Turk. Indeed, Beam's discloses a system that includes at least *both* low beam and high beam achieved by its microbeams. And as I have explained, high beam and low beam are aimed in *different* directions. Beam's microbeams *must* be able to change direction in order to achieve at least the high beam and low beam functions that a POSA would have understood. A POSA would have well understood that term of maximum intensity

is commonly relating to the light intensity level in different angles for different lamp functions. In particular, a POSA would have understood "maximum intensity" in the context of industry standards, government regulations, and automotive lighting settings, not by Dr. Turk's "intuitive-thinking."

93. And as I previously explained at paragraph 119 in my First Declaration, Beam discloses a plurality of headlights, each comprising a plurality of LED light sources that are configured as "an array of individual, independently controllable microbeam sources." EX1005, 8:4-17. Beam expressly discloses in claims 4 and 5 that the light source as referred to as comprising microbeams may be configured as an array of *individual, independently controllable LEDs*. EX1005, 2:53-3:3, 4:9-59, 8:4-17.

94. Additionally, I explained in paragraph 128 of my First Declaration that Beam's system "us[es] that information to *control the intensity, and/or the angular position*, of one or more" LEDs. *See* EX1005, Abstract. Beam thus explains that it *controls intensity including angular position* to a maximum desired in a given direction, and does not default (using a colloquialism) "full blast" everywhere at all times as Dr. Turk seems to suggest based on his misunderstanding of "intensity." Further, Beam's control is "*dynamically varying* in position and in size," in response to the control input. EX1005, 5:46-54, 6:24-27. So, what Beam discloses to a POSA is that Beam "determines a light change," and adapts the headlights'

light pattern in both intensity *and* spatial (angular) distribution as in the '503 patent's claims.

95. Dr. Turk also incorrectly states that "beam pattern" is "related to brightness and darkness of illumination within the shape." EX1054, 43:2-4. And this is in direct conflict with the Second Turk Declaration's paragraph 26, where he quotes *from an article that I co-authored*, explaining that "[a]ny automotive headlight beam pattern, either high-beam or low-beam, is a light luminous intensity (candela) angular distribution." EX2010, 237. Thus, a POSA would understand that such beam patterns relate to intensity with angular distribution.

96. As a POSA would have understood, Beam's beam pattern includes directionality, and a change in beam pattern includes a change in direction of the light. It is apparent to me that Dr. Turk does not understand Beam's disclosure from the perspective of a POSA. At paragraph 63 of EX2006, Dr. Turk states that Beam does not "disclose or teach changing direction of any microbeams," but this is fundamentally wrong. Beam expressly states that the *angular position* or *attenuation* (e.g., decrease as understood by Dr. Turk, EX1054, 95:12-23) "of each of these microbeams is independently set by controller 108," which is controlled in a dynamic environment of moving vehicles. EX1005, 4:46-54.

97. Because Beam's system is configured to adaptively change direction and selectively attenuate the microbeams, a POSA would have understood that

Beam's system can change the direction of the beam pattern, including using segments taught by Thominet. Accordingly, Beam-Thominet's headlight system provides a light beam "more direct, or active, of specifically aimed for different functions," as explained in my First Declaration. EX1003, ¶128.

98. Thus, a POSA would have been motivated to combine Thominet's multiple directional beam region controls with Beam's system without any conflicts.

2. Beam-Thominet's headlight provides sufficient forward illumination by actively directing beam segments for each particular driving function.

99. Dr. Turk's assertion that Thominet's multiple directional beam regions would "compromise" Beam's LED headlight from providing "sufficient forward illumination" (EX2006, ¶151) is wrong for failing to understand how Beam-Thominet's light beam would be actively directed to where illumination is desired for the driver.

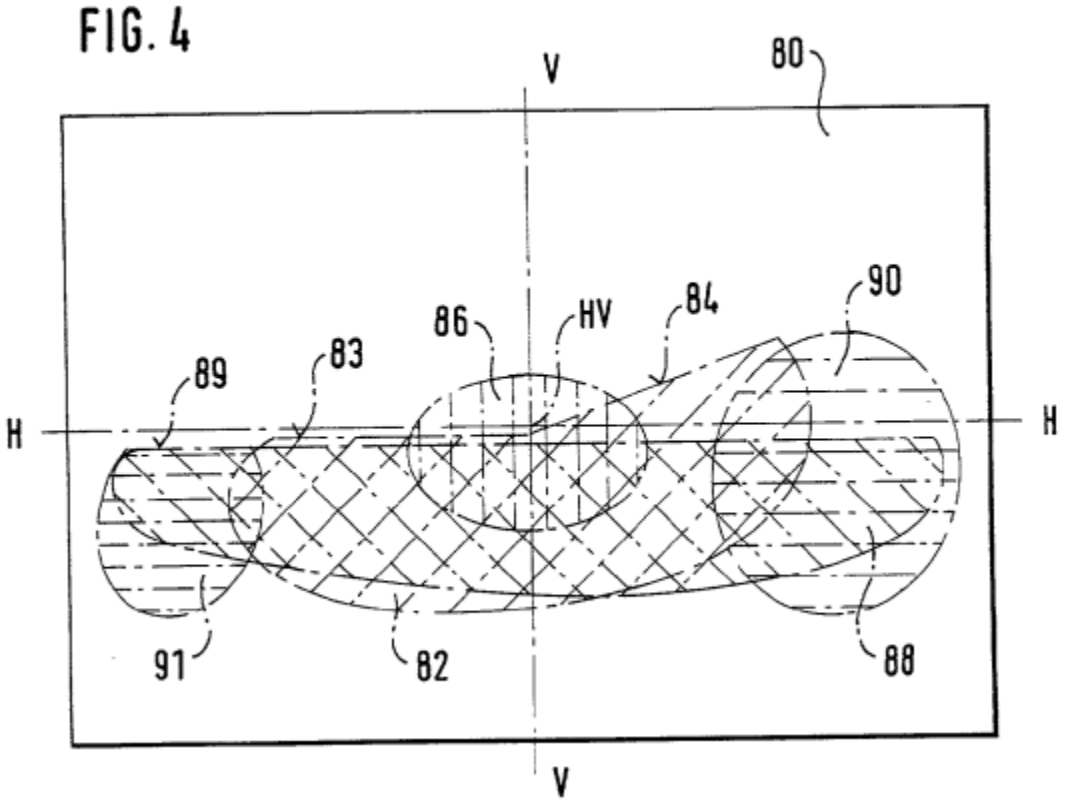
100. As explained in my First Declaration, employing "multiple directional beam regions with different angles/aimings in Beam's system, as in Thominet," would "provide different spatial distributions for improved visibility in different driving situations." EX1003, ¶123. My First Declaration explained that Thominet's known technique of using multiple directional beam regions for different functions would have been an "alternative control technique" for Beam's system to adjust

the light beam "for different driving situations." EX1003, ¶126. A POSA would have understood that Beam-Thominet's headlight system would have been "more direct, or active, or specifically aimed for different functions." EX1003, ¶128.

101. For example, a POSA would have understood that these different driving situations include driving at low speeds, in wet weather (e.g., fog, rain, and snow), and around road turns. EX1003, ¶164 ("low visibility, low/high speeds, recognizing a counter traffic, curves, etc."); EX1005, 3:33-37 ("It will also be possible to manually lower the beams for conditions like rain, snow, or fog, and again, as a backup in case of ABC system failure."); EX1023, 514-515 (describing to "tune[] the beam pattern in relations to driving, weather, and environment conditions," including "Bending," "Town driving," and "Adverse weather lighting (wet road, mist and fog)."); EX1017, 4.

102. Adding Thominet's multiple directional beam regions "would have provided Beam's system with different spatial distributions for different driving situations beyond reducing glare for drivers." EX1003, ¶160. In doing so, Beam-Thominet's light beam would have been spatially distributed to where illumination is desired for the driver according to the particular driving function. EX1003, ¶128. Thus, Beam-Thominet's LED/SLM headlight system provides *sufficient forward illumination* for each particular driving situation.

103. Dr. Turk further shows his misunderstanding of Beam by incorrectly asserting that Beam discourages attempts to control direction of the microbeams. EX2006, ¶153. A POSA would have understood that adjusting beam directionality according to driving conditions is consistent with Beam. For example, Beam describes adjusting the beam's spatial distribution "for conditions like rain, snow, or fog," as explained in my First Declaration. EX1005, 3:29-36; EX1003, ¶128.



EX1006, FIG. 4.

104. In addition, a POSA would have also understood that Thominet's "segment" concept shown in Figure 4, reproduced above, is in an angular domain. EX1006, FIG. 4; EX1003, ¶¶83-87. Each segment corresponds to the light emitted

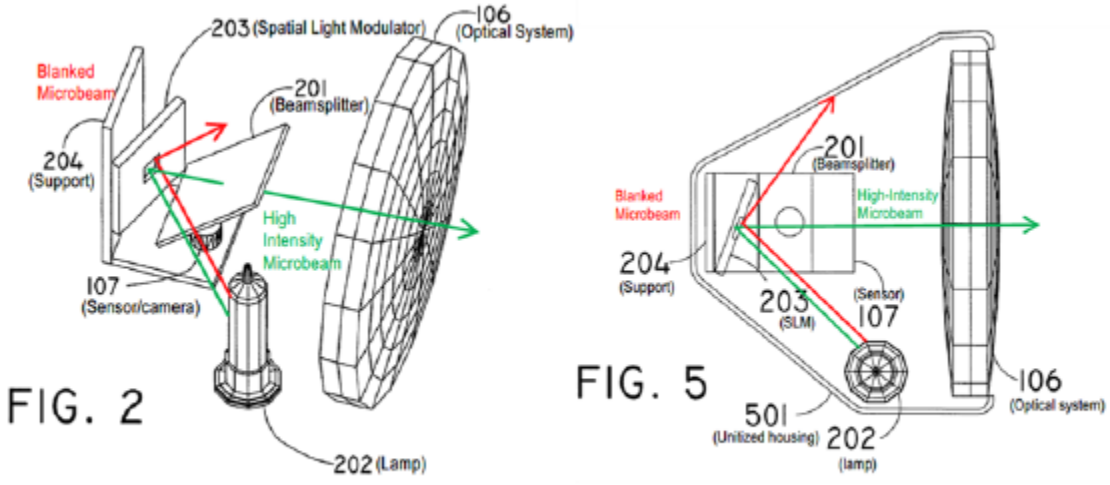
from the light sources to be aimed at the different angles. Thominet's control technique is similar to Beam's adaptive headlight system but with more defined "grouping" or "segment" in the different angular regions to allow easier control for the curved road, fog, and other desired beam patterns. Accordingly, using Thominet's clustered regions control with Beam's LED array would improve headlight performance, not compromise any illumination output requirements.

3. Beam-Thominet's lamp/LED/SLM controls the angular position of each microbeam to achieve different light beam patterns.

105. Dr. Turk mischaracterize Beam's SLM as not being able to adjust the angular position of the microbeams in an attempt to show that Beam's lamp/LED/SLM system is "wholly dissimilar" from Thominet's multiple beam segments. EX2006, ¶¶65-66, ¶134.

106. As I explained above in §VI.A.1, Beam's SLM shown in Figure 2 reflects microbeams at different aimings to "independently set" the "angular position" of each microbeam. EX1005, 4:45-57. A POSA would have understood that Beam's headlight system shown in Figures 2 and 4 outputs hundreds of thousands (e.g., 300,000) of microbeams "arranged in an X-Y matrix" and that the "*angular position* or attenuation of each these microbeams is *independently set by the controller 108*" sending command signals to SLM 203. EX1005, 4:45-57. That is, Beam's SLM 203 reflects microbeams at different aimings (and attenuates some

of the microbeams when glare light control is functioned). EX1005, 4:45-57, 8:9-12 ("spatial light modulator … consisting of digital mirror devices, liquid crystal devices, and grating light valves for selectively controlling the intensity of individual microbeam sources in said array."); EX1056, 19 ("SLMs may reflect or transmit the readout light, and modulate its intensity, phase, polarization, or *angle* depending on the light modulating medium."). In his Second Declaration, Dr. Turk provides an annotated version of Beam's Figure 2, reproduced below, that clearly demonstrates his lack of understanding of Beam's SLM. *See* EX2006, ¶¶65-66. Dr. Turk's notion that Beam's SLM 203 can only reflect light in the same direction or absorb light, without adjusting the angular position of the microbeam, is fundamentally wrong because Beam's SLM must have reflective functionality in order "to control the intensity, and/or the *angular position*, of one or more narrow-angle microbeams." (EX1005 Abstract.)



(Ex. 1005, FIGs. 2, 5, Annotated)

EX1005, FIGS. 2 and 5 (annotations from EX2006, 65).

107. By controlling the angular position of each microbeam through reflectivity, Beam's SLM can be programmed to segment the hundreds of thousands of microbeams arranged in the X-Y matrix according to the regions defined in Thominet. EX1005, 4:26-52. In doing so, Beam's system, as modified by Thominet, can achieve different spatial distribution of beam patterns for different driving situations. EX1003, ¶¶161-163. Thus, Beam-Thominet's SLM achieves different spatial distributions of beam patterns for different driving situations.

E. The Beam-Thominet combination discloses claim 25.

108. My First Declaration makes clear that Beam discloses "at least one of reflectors, refractors, or lenses usable to alter emitted light from at least one of the light sources" (EX1001, 98:39-42, claim 25) in the form of optical system 106 and SLM 203, which includes "digital mirror devices … for selectively controlling the intensity of individual microbeam sources in said array." EX1005, 8:4–12; EX1003, ¶199.

109. Dr. Turk does not dispute that Beam's SLM includes a reflector to alter emitted light. *See* EX2006, ¶¶178-179. Rather, Dr. Turk argues that Petitioner failed to show that SLM 203 is included with Beam's headlight system having an LED array, as shown Figure 4. *See* EX2006, ¶179. This is incorrect as I explained

above in §V.B, and as specifically taught by Beam, which recites LEDs and a spatial light modulator being present in the same device. EX1003, ¶151; EX1005, 8:1-12 ("wherein said light source [is] selected from the group consisting of light emitting diodes…and a special light modulator."); Section V.B. Dr. Turk does not otherwise dispute that the spatial light modulator is an optical control element. EX1053, 91:1-3 ("Q. A special [sic] light modulator or SLM is an optical control element, correct? A. It can be considered that, yes.").

110. Dr. Turk further argues optical system 106 is not a reflector, refractor, or lenses as recited in claim 25 because beam splitter 201 in Beam allegedly does not output reflected light. EX2006, ¶171. This is incorrect. A POSA would have understood that Beam's optical system 106 is a system that redirects input light to form a desired light output distribution, which is the underlying function of an optical system. EX1005, 5:17-21. A POSA would have understood that an optical system includes reflective, and/or refractive features based on well-known geometric optics principles. Having these reflective and/or refractive features means optical system 106 includes reflectors (for the reflective function) and refractors (for the refractive function).Thus, Dr. Turk's argument here is based on a misunderstanding of Beam and mischaracterization of my opinion. Beam discloses "at least one of reflectors, refractors, or lenses" of claim 25.

VII. PO'S SUBSTANTIVE ARGUMENTS AGAINST THE BEAM-THOMINET-STAM COMBINATION FAIL.

111. Both independent claims 20 and 59 recite limitations directed to a headlight with a processor determining a first subsection including a detected vehicle. Claim 59 adds an element specifying that the headlight system illuminates the first subsection below predefined illuminance and the second subsection above the predefined illuminance. The limitation "predefined illuminance" is addressed in my second ground, which combines Beam-Thominet with Stam. EX1003, ¶¶209-210, 253-288.

112. As explained in my First Declaration, a POSA would have understood that Beam's "default illumination level…equivalent of today's low beams" is a "predefined illuminance," as recited in claim 59. EX1003, ¶¶253-254; EX1005, 6:30-33 ("[T]he default illumination level will be the equivalent of today's low beam."). If the Board incorrectly finds that Beam does not disclose the recited "predefined illuminance," Stam does in the form of a specific dimmed illuminance value to reduce glare. EX1005, 3:8-44, 5:33-54, 6:53-7:13; EX1007, 1:14-31, 1:25-27. It would have been obvious to a POSA to provide a quantitative predefined dimmed illuminance level in the combined Beam-Thominet system, as in Stam, to further control Beam's directional microbeams to prevent glare, furthering the purpose of improving driver safety. EX1003, ¶¶2093-210, 261-270, 280-288;

EX1005, 3:8-14, 3:37-44, 5:33-54, 7:1-13; EX1007, 1:14-31, 9:12-10:8, Abstract, 58:11-33.

113. Dr. Turk does not dispute that Beam discloses a "predefined illuminance." *See* EX2006, ¶¶180-190. Instead, Dr. Turk contends that Beam-Thominet-Stam combination does not disclose a headlight system that determines a light output that illuminates the first subsection below a predefined illuminance, as recited in claim elements [59.8]-[59.9]. *See* EX2006, ¶¶183-184, 187-190. Dr. Turk further argues that there would have been no motivation to combine Stam's predefined illuminance with Beam's system. *See* EX2006, ¶¶183-184. All of these arguments are incorrect.

A. Beam's automotive adaptive headlight includes a processor determining "light output" that "illuminates the first subsection below a predefined illuminance" [59.8]–[59.9].

114. As explained in my First Declaration, Beam's headlight system illuminates the first subsection below a predefined illuminance by reducing illumination in the shaded areas corresponding to detected vehicles at a level "*significantly less* than with current *low beams*" EX1005, 2:66-3:1; EX1003, ¶¶253-254.

115. Dr. Turk contends that Beam's "utilizes a blanking strategy" that does not equate to determining illumination for the first subsection. *See* EX2006, ¶188, *see also* ¶¶172, 183-184, 187-190. Dr. Turk's characterization of Beam is

incorrect, failing to fully understand the teachings of Beam. When choosing to dim an area that includes the detected vehicle (the first subsection), Beam's controller 108 still determines a light output for the first subsection. EX1005, 5:33-6:9; EX1003, ¶¶253-254. Specifically, Beam's controller 108 determines to illuminate the first subsection at a level significantly less than current low beams. EX1005, 2:66-3:1. After determining what area in the field-of-view should be dimmed based on sensor data, Beam's controller then determines what individual microbeams to blank/attenuate/dim to illuminate the first subsection at a level below low beam. EX1005, 4:16-19 ("Data from sensor 107 are input to a controller 108, which uses them to *determine which microbeams must be reduced in intensity* to protect the other drivers."), 5:33-6:9. Accordingly, a POSA would have understood that Beam's blanking of microbeams to prevent glare toward drivers includes the preceding processing steps of detecting vehicles and determining an area to be illuminated below low beam. EX1003, ¶¶253-254.

116. Furthermore, Dr. Turk's assertion that Beam's blanking strategy "provides no illumination directed at the 'blanked area'" is inaccurate and contradicted by Beam's disclosure. EX2006, ¶188. Dr. Turk fails to recognize that the blanked area corresponding to the detected vehicles is still illuminated but at "reduced significantly" compared to the remaining areas of the headlights' field-of-view. EX1005, 4:19-25. Beam describes that "the area of the beam that would

dazzle the driver will be darkened," not completely darkened. EX1005, 2:60-61. Thus, Beam's headlight system does determine to illuminate a first subsection below a predefined illuminance, as recited in claim 59.

B. A POSA would have been motivated to combine Stam's predefined low-beam illuminance level with Beam-Thominet.

117. Dr. Turk alleges that there would have been no motivation to combine Stam's predefined threshold with Beam's headlight system because Beam's blanking strategy eliminates the need for Stam's predefined illuminance. EX2006, ¶185. Dr. Turk again bases his argument on the inaccurate characterization that Beam's controller solely blanks microbeams without determining an illumination output for the area corresponding to the detected vehicle. But as I explained above in §VII.A, Beam's blanking of microbeams to prevent glare toward drivers includes the preceding processing steps of detecting vehicles and determining an area to be illuminated below low beam. A POSA would have understood that implementing clarified or quantitative predefined dimmed illuminance level in the combined Beam-Thominet system, as in Stam, would ensure that the light output remains lower, furthering Beam's goal of reducing glare.

C. Beam-Thominet-Stam combination discloses claim 64.

118. My First Declaration makes clear that there are no patentable differences between claims 25 and 64, which both recite "wherein at least one of the one or more headlights further includes at least one of reflectors, refractors, or

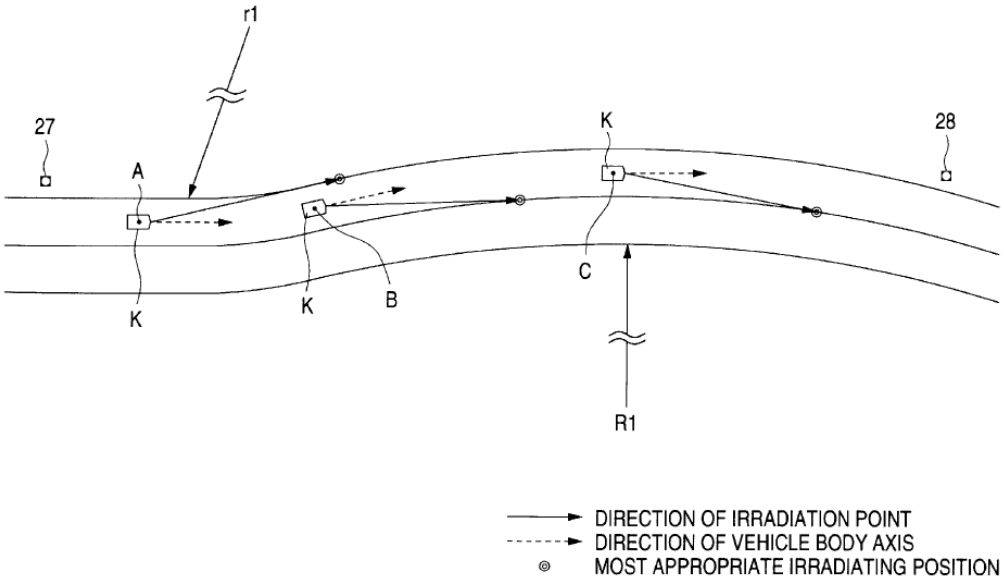
lenses usable to alter the light emitted from at least one of the light sources." EX1001, 98:39-42 (claim 25), 102:57-61 (claim 64). Claim 64 only differs from claim 25 by adding the phrase "as part of the instructed adjustment," which does not patentably distinguish claim 64 from claim 25. EX1001, 98:39-42 (claim 25), 102:57-61 (claim 64). As demonstrated in my First Declaration, Beam's SLM includes "digital mirror devices," which are controlled by Beam's controller such that Beam's digital mirrors alter light "as part of the instructed adjustment" (claim 64) by Beam's controller. EX1003, ¶¶199-200, 293-295; EX1005, 4:10-59, 8:8-11.

119. Dr. Turk takes issue with the "as part of the instructed adjustment" difference between claims 25 and 64. EX1003, ¶116-117. But I fail to see any patentable distinctions. As explained in my First Declaration and my analysis above in §V, Beam's SLM 203 alters light emitted from Beam's lamp 202 shown in Figure 2 and LEDs 404 shown in Figure 4 by a command signal transmitted by controller 108 to control the angular position of the outputted microbeams. EX1003, ¶¶78, 199; EX1005, 4:53-59 ("[C]ontroller 108 … then commands spatial light modulator 203 in illuminator 109 to either divert the selected microbeams or to attenuate them, depending on the implementation of spatial light modulator 203 chosen.") During his deposition, Dr. Turk also confirmed that Beam's SLM 203 includes reflectors that alter light as part of the adjustment by Beam's controller 108. EX1052, 88:7-10 ("I don't think Beam teaches the

controller reducing the microbeams by any other means except for diverting them by mirror to go out of the device or to be absorbed inside the device.") Thus, as acknowledged by Dr. Turk, Beam discloses "at least one of reflectors, refractors, or lenses," as recited in claim 64.

VIII. PO'S SUBSTANTIVE ARGUMENTS AGAINST THE BEAM-THOMINET-KOBAYASHI AND BEAM-THOMINET-STAM-KOBAYASHI COMBINATIONS FAIL.

120. The road curvature claims are dependent claims 21-23 and 60-62, which add elements related to illuminating road curvatures. Claims 21-23 are addressed by my third Ground, which combines Beam, Thominet, and Kobayashi, and claims 60-62 are addressed by my fourth ground which combines Beam, Thominet, Stam, and Kobayashi. EX1003, §§XII-XIII. As explained in my First Declaration, Kobayashi teaches to control the shape of the headlight beam "[a]ccording to the road profile information" based on map data such that when a vehicle turns left, the left shoulder is irradiated, and when the vehicle turns right, the right shoulder is irradiated. EX1008, 14:53-15:28, FIG. 10; EX1003, ¶¶300-302. My First Declaration makes clear that a POSA would have been motivated to modify Beam-Thominet to adjust light based on road curvature, as in Kobayashi, to further control Beam's directional microbeams to illuminate roadway curves, thereby improving driver safety. EX1003, ¶¶303-317.



EX1008, FIG. 10.

121. Dr. Turk argues that these combinations do not teach the curvature element of "to increase illumination in a direction of the road curvature," as recited in claims 21-23. EX2006, ¶¶194-199. Dr. Turk further argues that my First Declaration did not address all the limitations recited in claims 60-62. EX2006, ¶¶117, 203. Dr. Turk again premises his arguments on a misunderstanding of how Beam functions. Dr. Turk's analysis also fails because he does not fully consider the combination explained in my First Declaration.

A. The Beam-Thominet-Kobayashi combination renders obvious a headlight configured to "increase illumination in a direction of the road curvature."

122. Dr. Turk's assertion that Beam's system would have no unlit LEDs to increase illumination in a direction of the road curvature, as recited in claims 21-23, is based on a misunderstanding of what "intensity" means in the art. EX2006,

¶¶195-198. As I explained above in §VI.D.3, Beam *controls intensity, including angular position,* to a maximum desired in a given direction, and does not default to "maximally illuminating everything" as purported Dr. Turk. EX2006, ¶197.

123. Dr. Turk misunderstands what Beam discloses to a POSA. Beam discloses a system that includes at least *both* low beam and high beam achieved by its microbeams. EX1005, 3:29-36, 6:40-44. And as I have explained, high beam and low beam are aimed in *different* directions. Section IV.A.1-2; EX1003, ¶203 (citing EX1005, 6:30-33). Beam's microbeams *must* be able to change direction in order to achieve at least the high beam and low beam functions that a POSA would have readily understood. Beam does not, however, disclose to a POSA that it is unable to *increase light in a direction* by virtue of its "maximum intensity"—which is not "maximum brightness." A POSA would have well understood that the term "maximum intensity" is related to the light intensity level that varies in different angles for different headlight functions (such as high beam or low beam).

124. Beam discloses a plurality of headlights, each comprising a plurality of LED light sources, which may be configured as "an array of individual, independently controllable microbeam sources." EX1005, 8:4-17. Beam expressly discloses in claims 4 and 5 that the light source as referred to as comprising microbeams may be configured as an array of *individual, independently controllable LEDs*. EX1005, 2:53-3:3, 4:9-59, 8:4-17.

125. Additionally, I explained in paragraph 128 of my First Declaration that Beam's system "us[es] that information to *control the intensity, and/or the angular position*, of one or more" LEDs. *See* EX1005, Abstract. Beam thus explains that it *controls intensity including angular position* to a maximum desired in a given direction, and does not default to "illuminating everything it can" at all times as Dr. Turk suggests based on his misunderstanding of "intensity." EX2006, ¶197. Further, Beam's control is "*dynamically varying* in position and in size," in response to the control input. EX1005, 5:46-54, 6:24-27. So, what Beam discloses to a POSA is that Beam "determines a light change," and adapts the headlights' light pattern in both intensity *and* spatial (angular) distribution as in the '503 patent's claims.

126. Given that a POSA would have understood that maximum intensity of a headlight beam depends on the beam's angular distribution and where the vehicle is directed, a POSA would have been motivated to modify Beam-Thominet's light output based on road curvature, as in Kobayashi, to further control Beam's directional microbeams to illuminate roadway curves, thereby improving driver safety. EX1003, ¶¶303-317. Beam expressly states that the *angular position* or *attenuation* "of each of these microbeams is independently set by controller 108," which is controlled in a dynamic environment of moving vehicles. EX1005, 4:46-54. Implementing Kobayashi's known technique of using map data including road

curvature as an additional data source for Beam-Thominet's controller to adjust *angular position* of the microbeams would have increased illumination toward the road curvature, further improving safety.

127. Thus, a POSA would have been motivated to combine Kobayashi with Beam-Thominet and Beam-Thominet-Stam to render obvious the increase of illumination toward the road curvature, as recited in claims 21-23 and 60-62.

B. Beam-Thominet-Stam-Kobayashi combination renders every limitation of claims 60-62 obvious.

128. My First Declaration makes clear that there are no patentable differences between claims 21-23 and claims 60-62, which both sets of claims are directed to road curvature limitations. EX1001, 98:22-35 (claims 21-23), 102:41-53 (claims 60-62). As shown in the Table below, claims 21-23 recite "direct the control circuitry to adjust the directional light sources" to increase illumination in a direction of the road curvature, whereas claims 60-62 recite "determine light output that aims illumination in a direction of the road curvature." EX1001, 98:22-35 (claims 21-23), 102:41-53 (claims 60-62). While claims 21-23 and 60-62 do not recite the exact same claim language, the subject matter of claims 60-62 is not patentably distinct from claims 21-23, as explained below.

Claim	Language	Claim	Language
21	wherein the processor is further configured to determine at least a road curvature, indicated by the	60	wherein at least one of the at least one processors is further configured to determine at least a road

Claim	Language	Claim	Language
	sensor data, ahead of the vehicle and to **direct the control circuitry to adjust the directional light sources to increase illumination** in a direction of the road curvature.		curvature, indicated by the sensor data, ahead of the first vehicle and to **determine light output that aims illumination in a direction of the road curvature**.
22	wherein the processor is further configured to determine at least a planned upcoming turn, indicated by the sensor data, and to **direct the control circuitry to increase illumination** illuminating the turn	61	wherein at least one of the at least one processors is further configured to determine at least a planned upcoming turn, indicated by the sensor data, and to **determine light output that illuminates the turn**.
23	wherein the processor is further configured to determine at least a planned upcoming turn, indicated by the sensor data, and to **direct the control circuitry to increase illumination** illuminating the turn	62	wherein at least one of the at least one processors is further configured to determine at least a planned upcoming turn, indicated by the sensor data, and to **determine light output that illuminates the turn**.

129. As explained above in §VIII.A, a change in direction of the beam reflects a change in intensity. Changing a direction of a beam in a direction of the curvature increases light in a direction of the curvature. Accordingly, a POSA would have understood that aiming illumination in a direction of the road curvature equates to increasing illumination in a direction of the road curvature. A POSA would have also understood that directing control circuitry to increase illumination would include determining a light output to illuminate the turn. Specifically, a POSA would have understood an automotive headlight controller would determine a light output before commanding the light source to emit a light beam.

Accordingly, by showing how the Beam-Thominet-Kobayashi combination renders obvious the road curvature claims 21-23, my First Declaration also showed how the Beam-Thominet-Stam-Kobayashi combination renders obvious the road curvature claims 60-62.

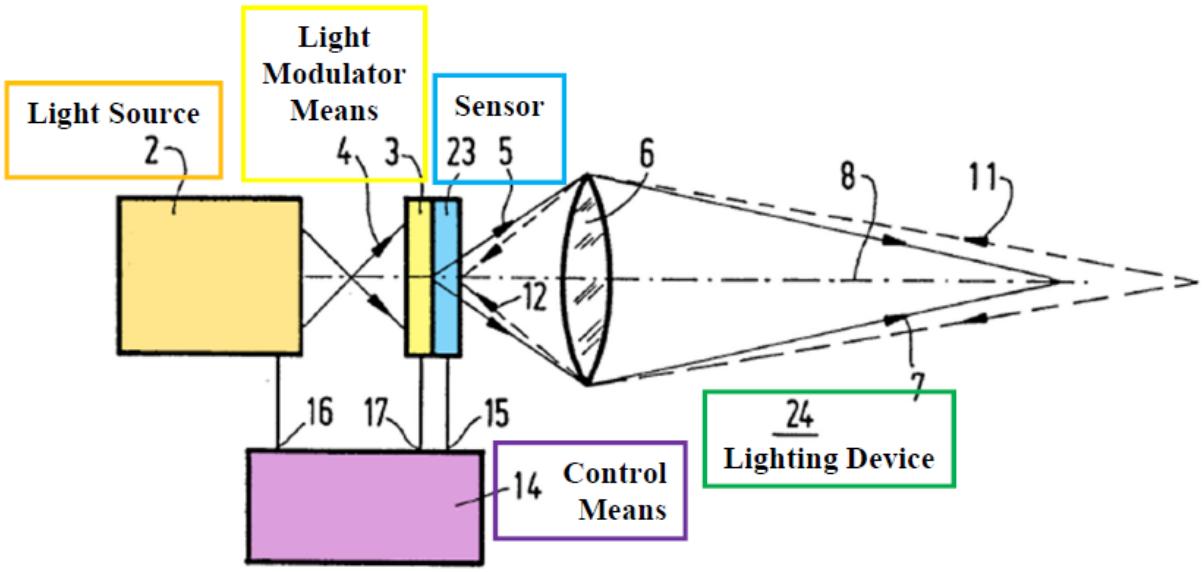
IX. PO'S SUBSTANTIVE ARGUMENTS AGAINST THE KARLSSON-HARBERS COMBINATION FAIL.

130. Dr. Turk's substantive arguments against the Karlsson-Harbers combination are not correct, and I believe they are based upon his fundamental misunderstandings of the art as I have laid out above.

A. The Karlsson-Harbers combination discloses at least three directional light sources aimed at different angles, as recited in [20.2].

1. Karlsson's spotlight sources are "directional light sources."

131. My First Declaration makes clear that Karlsson's lighting device includes at least three directional light sources aimed at different angles relative to the vehicle in the form of "spotlight beams 34." EX1010, 4:25-31, 14:5-15, FIGS. 3, 6; 11:25-28 ("*given directions*"), 14:1-4 ("spotlight beams 34 can be…a *grid of separate light sources*"), 19:29-33 ("desired pattern and *direction of the beam*"), FIG. 14; EX1003, ¶¶368-369. A POSA would have understood that Karlsson's spotlight beams 34 include "a plurality of light sources and/or light modulators" that are configured to direct the spotlight beams 34 in at least three different angles relative to the vehicle. EX1010, 21:12-16; EX1003, ¶333.



EX1010, FIG. 3 (annotations from EX1003, ¶368).

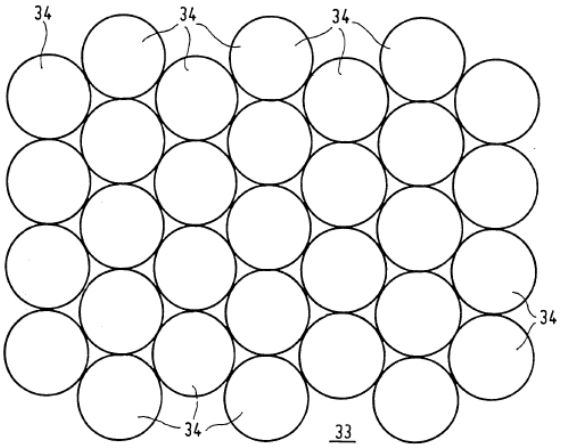
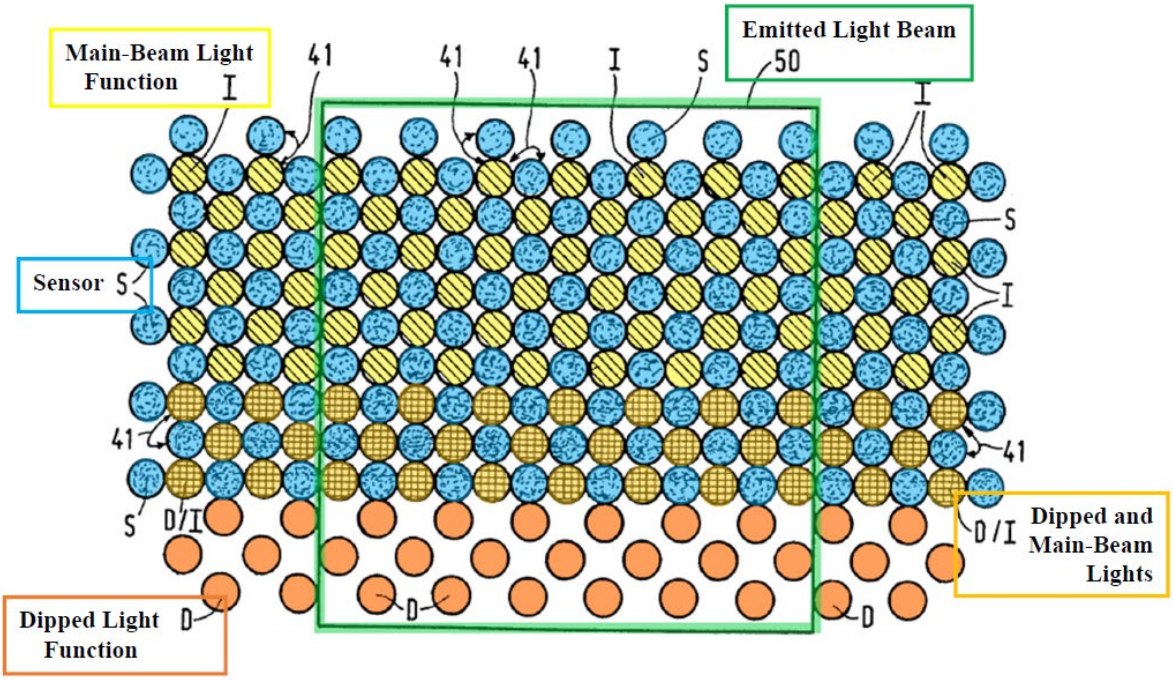


FIG. 6

EX1010, FIG. 6.



EX1010, FIG. 14 (annotations from EX1003, ¶368).

132. I understand that the Board disagreed with the analysis in my First Declaration, finding that Karlsson's light modulator means for its "spotlight beams" do "not project[] light in different directions" but rather "detect[] light from different directions." DI, 14. Dr. Turk agreed with the Board's position, asserting that Karlsson's light modulator means 3 detects light "from different directions to control intensity, not projecting light in different directions." EX2006, ¶217. Dr. Turk's characterizations of Karlsson's spotlight sources are incorrect, while the Board appeared to overlook a pertinent section of Karlsson (EX1010, 14:1-15) cited in my first Declaration. EX1003, 333 (citing EX1010, 14:1-15).

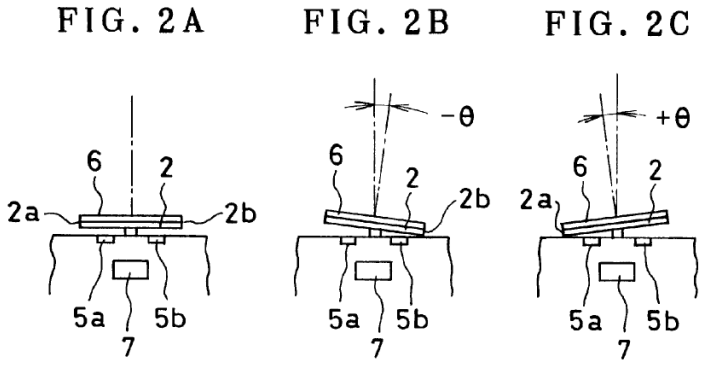
133. A POSA would have understood that Karlsson's spotlight beams include both an emitter and an optical element to control the intensity and the

angular position of the spotlight beams. *See*, *e.g.*, EX1003, ¶¶70, 333. Indeed, as I previously explained, a POSA would have understood that Karlsson's "'light sources' includes … *the combination of light sources and spatial light modulators*, for example, microbeam sources and *spotlight beam sources*." *Id.* As I discussed above in §VI.A.1, to be "directional," in the context of automotive lighting and the '503 patent, the emitter of the light source must be combined with an optical element because a light emitter, without an optical element to collect and collimate light, will not be directional. A POSA would have understood that any electrical light emitting source, such as an incandescent filament, or a high-intensity discharge arc, or an LED die, etc., is integrated with an optical element to make the light emission as a "directional light source," as recited in claim 20. EX1001, 97:61-66. As an example, Karlsson's lighting device combines an emitter, such as Karlsson's "grid of separate light sources" (EX1010, 14:1-4), with a "grid of light modulators" (EX1010, 14:5-6) to output a plurality of spotlight beams 34 aimed in at least three directions. As such, Karlsson's spotlight beam sources are "directional light sources" under the plain meaning of the claims language.

134. Dr. Turk's assertion that the Karlsson's modulator cannot control the direction of the spotlight beams 34 is incorrect. Karlsson's light modulator means is "built up of a grid of light modulators[,] which can be switched individually to transmit light, to block light and/or to reflect light." EX1010, 14:5-9. As explained

in my First Declaration, a POSA would have understood that Karlsson's grid of modulators allow light to be aimed at different angles by reflecting light. EX1003, ¶¶368-369; EX1010, 14:9-15. Karlsson describes its modulators are "controlled to transmit light to a specified degree, so that a desired light intensity can be adjusted for each individual spotlight beam 34." EX1010, 4:1-15.

135. While not relied on for showing the unpatentability of the challenged claims of the '503 patent, a POSA would have known, for example, from Enomoto, that modulators can be controlled to reflect light (e.g., spotlight beams) at particular angles. As demonstrated in FIGS. 2A-2C of Enomoto, some light modulators, such as the modulators described in Karlsson, can deflect the outputted light beam off a normal axis. EX1040, Abstract, 1:16-30, 4:52-5:4. A POSA would have understood that Karlsson's disclosure of modulators on page 14, lines 12-15 have the capability to reflect light as described in Enomoto.



EX1040, FIGS. 2A-2C.

2. Harbers's curved substrate includes "at least three directional light sources aimed at different angles."

136. I agree with the Board's finding in the Institution Decision that Harbers's headlight includes a plurality of light sources arranged at different sources. DI, 15-16. My First Declaration explained that Harbers's headlight includes "at least three directional light sources aimed at different angles" in the form of independently controllable opto-electronic elements 11-14 arranged on a curved substrate that emits light beam segments 6-6'-6"-6"', 7-7'-7"-7"' with different angles/aimings relative to longitudinal direction 9 for different spatial distributions. EX1011, 5:14-26, 6:1-7, 6:27-7:19, FIGS. 1B, 2; EX1011, 7:27-32 ("*curved substrate*…*determined* to a substantial degree by the *desired direction* of the light beams emitted"); EX1003, ¶371.

137. Dr. Turk does not dispute that Harbers's headlights includes at least three directional light sources aimed at different angles, as recited claims 20 and 59. Rather, Dr. Turk contends that my First Declaration failed to show how Harbers's array of opto-electronic elements would have been implemented on a curved substrate in Karlsson's system that includes interspersed light sensors. EX2006, ¶220.

138. Dr. Turk's argument is incorrect because implementing LEDs and sensors on a curved substrate was well within the level of ordinary skill in the art. As demonstrated in both Thominet and Harbers, it was well known at the time of

the '503 patent's invention to provide a plurality of light sources on a curved substrate. EX1003, 358; EX1011, 7:22-33; EX1006, ¶18. When asked during his deposition whether "a person skilled in the art [would] have understood how to implement light sources on a curved substrate," Dr. Turk acknowledges that, "I think a person of ordinary skill in the art would know how to mount them and probably connect them electronically and some other things you would want to do." EX1052, 101:13-22. Dr. Turk's admission in his deposition that mounting a plurality of electronic components on a curved substrate contradicts his argument set forth in paragraph 220 of his Second Declaration. As Dr. Turk acknowledged during this deposition and explained in my First Declaration, mounting a plurality of light sources with a plurality of interspersed sensors on a curved substrate would have been routine for a skilled artisan. EX1003, ¶¶358-359. Thus, combining the teachings of Harbers's curved substrate with Karlsson's multiple light source headlight renders obvious "at least three directional light sources aimed at different angles."

B. Karlsson's automotive adaptive headlight system includes a processor determining a "first subsection" [20.9]/[59.7].

139. I agree with the Board's finding that Karlsson's headlight includes a processor that processes sensor data to determine, within a field-of-view, a first-subsection including a detected vehicle. DI, 20. My First Declaration explained that controller 14 of Karlsson's headlight system receives an input 15 from light-

sensitive sensor 9 corresponding to detection of incident light 11. EX1010, 9:9-18. Karlsson's sensor 9 detects "light from oncoming traffic as a parameter to which the pattern of the emitted light beam is to be adjusted." EX1010, 5:16-19. Karlsson describes that light beam 7 is "controlled in such a manner that … light having a low intensity is emitted in those directions from which light is detected by the light-sensitive sensor" such that "glaring or blinding of oncoming traffic is effectively prevent." EX1010, 9:22-25. Accordingly, a POSA would have understood that area corresponding to the detected headlights of the "oncoming traffic" in Karlsson is the recited "first subsection" and that Karlsson's controller determines this first-subsection in the headlights' field-of-view based on data from light-sensitive sensor 9. EX1003, ¶408.

140. Dr. Turk contends that Karlsson's controller does not determine a first subsection, as recited in claim 20, because Karlsson's controller "is agnostic to the source of the incoming light and does not discloses any processing of the spotlight sensor signals to determine whether the source is a vehicle." EX2006, ¶227. Dr. Turk's arguments are incorrect or irrelevant for multiple reasons.

141. First, Dr. Turk again relies on the same unclaimed feature—the processor being able to differentiate between different types of light sources—in an attempt to distinguish the claims over Karlsson's headlight system. As I explained above in §VI.B.1 and acknowledged by Dr. Turk in his deposition, claims 20 and

59 do not recite any limitations specifying how the processor determines the presence of a vehicle. Claim element [20.9] recites "the processor, in communication with at least the sensors and the control circuitry, configured to: process the sensor data to determine, within a field-of-view, at least a first subsection including a detected vehicle." EX1001, 98:10-14. Claim element [59.7] recites "wherein the at least one processor is configured to: process the sensor data to identify a first subsection, of a field of view, that includes at least a portion of the second vehicle."

142. Karlsson's controller "automatically and dynamically adapt[s]" the "pattern of the light beam being emitted by the lighting device … in dependence on the intensity and the direction of the light being detected" such that "part of the light beam which might cause inconvenience to oncoming traffic is automatically suppressed." EX1010, 2:4-9. A POSA would have understood that Karlsson's headlight controller detects vehicles by using a light-sensitive sensor to detect vehicle headlights. EX1010, 9:9-25, 14:1-15; EX1003, ¶¶408-409; DI, 20. Thus, Karlsson's headlight system meets the plain language of claim elements [20.9] and [59.7], regardless of whether Karlsson's headlights dim light at other types of light sources.

143. Second, PO's and Dr. Turk's alleged distinctive feature of claims 20 and 59—using pattern recognition to detect vehicles for anti-glare control—is not

commensurate with the vehicle detection methods described in '503 patent specification for anti-glare control. POR, 70; EX2006, ¶227; EX1001, 50:35-58, 52:66-53:2. Karlsson's detection of vehicle headlights to determine the position of an oncoming vehicle relative to the headlight is consistent with the methods described in the '503 patent. *Compare* EX1001, 50:53-58, 52:66-53:2 *with* EX1010, 9:9-25.

144. Third, a POSA would have understood that Karlsson's system is able to distinguish between light sources when determining the presence of a vehicle relative to the headlights. Karlsson describes that the "pattern of the light beam being emitted by the lighting device is automatically and dynamically adapted in dependence on the intensity and the direction of the light being detected" such that "part of the light beam which might cause inconvenience to oncoming traffic is automatically suppressed." EX1010, 2:4-9. A POSA would have understood that Beam's controller can distinguish between light sources by detecting both the direction and intensity of the incident light. Furthermore, Karlsson further describes that the headlight system is able to discern between ambient light and light from oncoming traffic. EX1010, 5:16-17. Thus, Karlsson's headlight controller even meets Dr. Turk's unsupported claim requirements.

145. Fourth, Dr. Turk's pattern recognition techniques were known in the art and would have been straightforward to be employed into Karlsson's system.

Specifically, the '503 patent describes that "[p]attern recognition methods [are] known in the art, including neural networks." EX1001, 44:64-66. The '503 patent further acknowledges:

> Outputs from the CCD arrays are analyzed by appropriate computational means employing trained pattern recognition technologies, to classify, identify or locate the contents. These *techniques known in the art* are covered in texts such as Schalkhoff, Pattern Recognition, statistical, structural and neural approaches, John Wiley and Sons, New York, 1992 and Neural Networks for Pattern Recognition by Christopher M. Bishop, Chis Bishop, Oxford University Press; (January 1996) included herein by reference.

EX1001, 45:1-8.

C. A POSA would have been motivated to combine Harbers's curved substrate with Karlsson's spotlight array.

146. As explained in my First Declaration, a POSA would have been motivated to substitute a curved LED substrate, as taught in Harbers, for Karlsson's flat LED substrate, *at least because* the light sources would be physically aimed at different angles, thereby improving optical performance of the headlight system. EX1003, ¶¶354-359, 384-389.

147. Dr. Turk contends that there would have been no motivation to combine the teachings of Harbers's curved substrate alone with Karlsson's

headlight system because Harbers's software is needed to achieve the advantages associated with segment control. EX2006, ¶206.

148. Dr. Turk's arguments reflect a lack of understanding of the art and what Harbers's curved substrate would have suggested to a POSA. It is not clear to me whether Dr. Turk read any of the paragraphs [0354]-[0359] and [384-0389] of my First Declaration addressing exactly this issue. Nonetheless, a POSA would have been motivated to substitute a curved LED substrate for a flat LED substrate as laid out in paragraphs [0354]-[0359] and [384-0389] of my First Declaration. Furthermore, a POSA would not have been discouraged from implementing Harbers's curved substrate with an anti-glare headlight system, such as Karlsson's system.

149. Rearranging Karlsson's LEDs on a curved surface, as taught in Harbers, would have yielded the predictable result of providing different spatial distributions for different driving situations. EX1003, ¶354. In doing so, Beam-Thominet's headlight systems would "improve[e] visibility and thereby safety." EX1003, ¶¶354-359, 384-389.

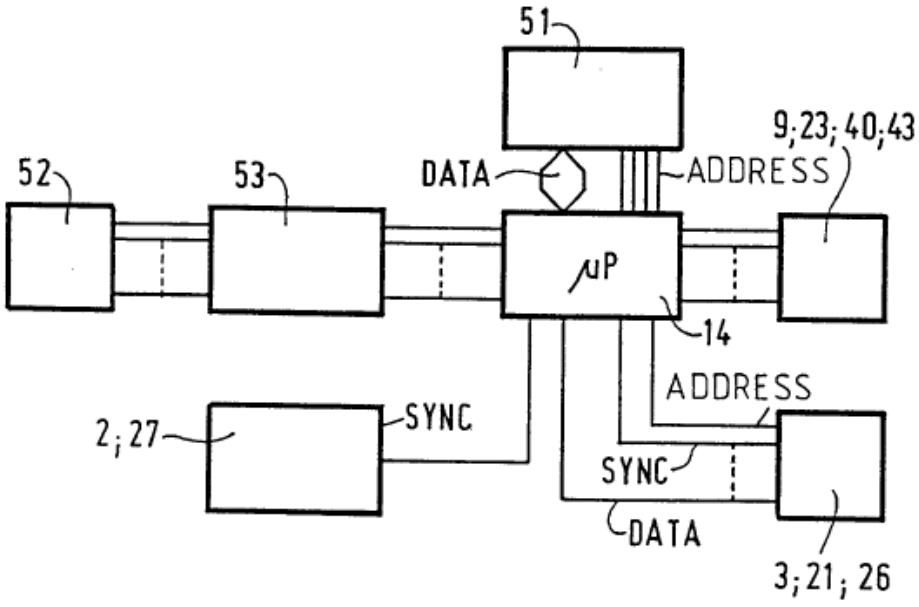
150. In response to Dr. Turk's unsupported argument (EX2006, ¶¶142-147, 206), a POSA seeking to improve driver visibility by modifying headlights—as explained in my First Declaration—would have readily known that curved substrates enhance the headlight's optical performance. As I explained above in

§VI.C, a POSA would have understood that using angular-sectional beam contributors, such Harbers's curved LED arrangement, simplifies the optical element design for headlights by reducing aberration. Thus, a POSA would have preferred using a curved substrate over a flat substrate for a vehicle headlight. As I explained in my First Declaration, this is a rather simple hardware combination by forming the Karlsson's flat LEDs array panel to a curved panel taught by Harbers. EX1003, ¶¶354-359. Accordingly, combining Harbers's different color LEDs with Karlsson would not create color shifting problems.

D. A POSA would have been motivated to combine Harbers's multi-function beam segments with Karlsson's adaptive headlight system to improve driver visibility.

151. My First Declaration makes clear that a POSA would have been motivated to combine Harbers's multiple direction beam segment technique with Karlsson to provide "different spatial/angular distributions for different driving situations, thereby improving driver safety." EX1003, ¶351, *see also* ¶¶373-382. Karlsson's and Harbers's software operate similarly by controlling individual or group of LEDs' directions and intensities, along with the LEDs' modulator(s). EX1010, 13:24-14:15; EX1011, 8:21-28. Harbers teaches to add segment/angular-region control and colored LED control for the purpose of enhancing road illumination and driver safety. EX1011, 8:21-8:28. A POSA would have been motivated to provide the same segment/angular-region control, as taught by

Harbers, with Karlsson's system for enhancing road illumination. EX1003, ¶¶343-359, 373-382. A POSA would have also understood how to implement Harbers's multi-function beam segments with Karlsson's adaptive headlight system to adapt the headlight beam for different driving scenarios. EX1003, ¶353.



EX1010, FIG. 15.

152. Dr. Turk opines that a POSA would not have been motivated to combine the teachings of Harbers's multiple direction beam region technique with Karlsson because Karlsson's optimal light beam adaption strategy allegedly conflicts with Harbers's segment control strategy. EX2006, ¶¶88, 207, 223. Dr. Turk speculates that "Harbers control … may try to widen a beam (due to a slowing vehicle) that Karlsson is controlling as in Petitioner's annotated Fig. 14," which would allegedly "place light where Karlsson is intentionally removing it"

and "dim forward illumination" where "Karlsson is attempting to utilize at full output." EX2006, ¶207.

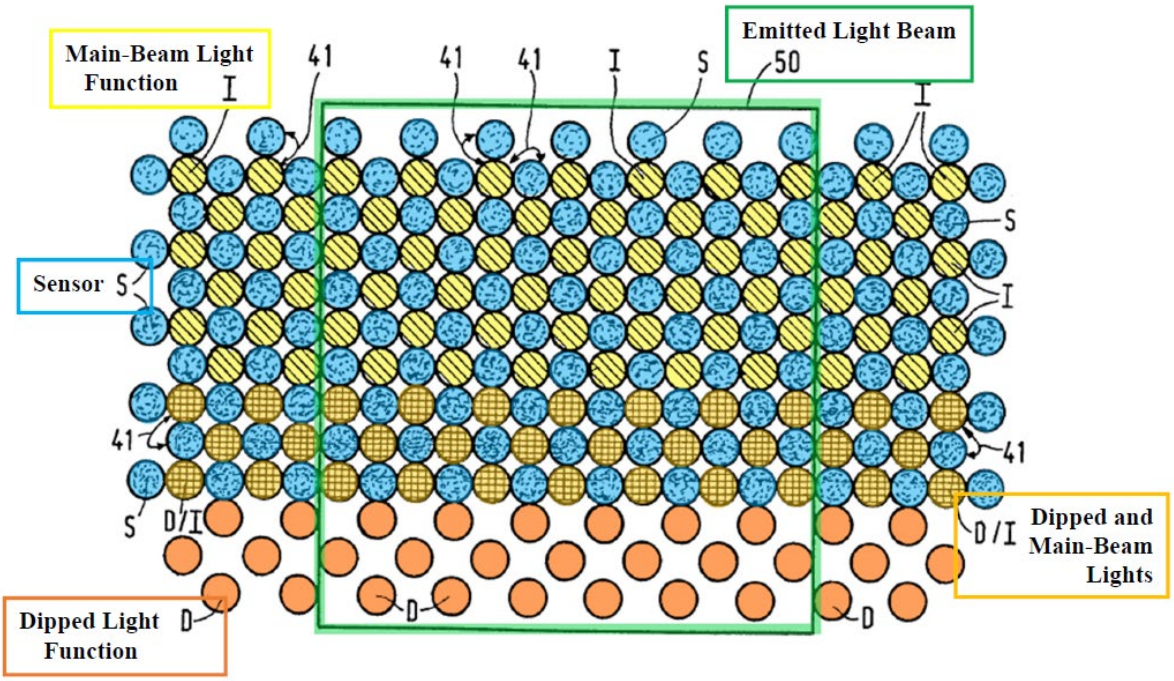
153. This hypothetical described in paragraph 207 of Dr. Turk's Second Declaration clearly indicates Dr. Turk's misunderstanding of the art and his lack of experience in automotive lighting practice. Dr. Turk's arguments are further flawed for failing to recognize my rationales for combining Karlsson and Harbers and grossly mischaracterizing Karlsson's headlights as a binary system.

1. Dr. Turk misunderstands Karlsson's "optimally adapted" beam.

154. Dr. Turk draws an unsupported and incorrect conclusion that Karlsson forms emitted beam 7 through "full usage of the array except when accommodating glare." EX2006, ¶213. Further in paragraph 88 of the Second Turk Declaration (EX2006), Dr. Turk states that "Karlsson, like Beam, forms emitted beam 7 (Fig. 1) by using the entire beam array at full intensity, except when avoiding glare, at which point, window 50, of reduced illumination (Fig. 14) is created to address glare situations." EX2006, ¶88. These are gross misstatements of what Karlsson discloses to a POSA. Karlsson does not disclose full or maximum intensity at all times except to reduce glare.

155. As explained in my First Declaration (EX1003, ¶¶102-103), Karlsson's emitted light beam 50 is represented as a window that can shift in the

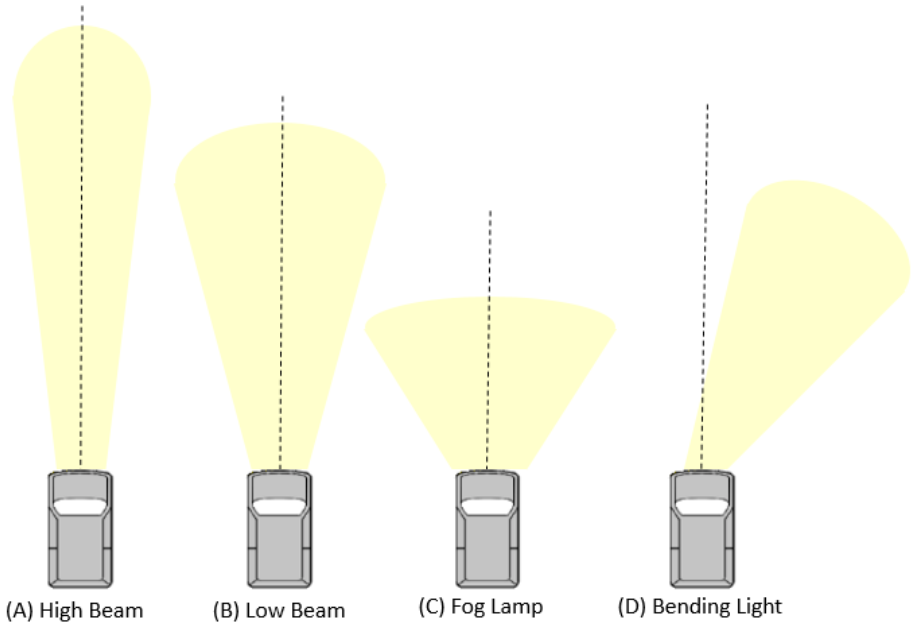
plane from left to right and from top to bottom and produced by LEDs based on the data from inputs, e.g., data sensed from spotlight sensors S. EX1010, 19:18-20.



EX1010, FIG. 14 (annotations from EX1003, ¶368).

156. The annotation demonstrates the variability of Karlsson's spotlight beam. Karlsson expressly states that "[t]he *emitted light beam 50 is represented as a window* which can *shift* in the plane of the drawings *from the left to the right* and *from the top to the bottom*, if desired, and vice versa, and which may *vary as regards its shape* and *dimension* in dependence on the *desired pattern* and *direction of the beam*." EX1010, 19:29-33; EX1003, ¶91. A POSA would not find anything unclear about this statement in Karlsson. Below, I illustrate several beam patterns that Karlsson would create via its emitted light beam based in part on the

section quoted above from Karlsson's beam (supporting that Karlsson discloses an adaptable beam):



Examples of Karlsson's "Desired Beam Pattern."

157. The left-most figure shows a schematic of a high-beam pattern, which is long with a narrower angle of beam spread. The figure next to that shows a low beam pattern—still relatively long and wider spread. The third-from-left figure illustrates a fog lamp beam pattern—low and wider still, ideal to increase short-range visibility and safety. Finally, the right-most figure shows a beam aimed towards the right, for example, towards a right-handed curve (e.g., when using Gotou's control strategy to aim light in the direction towards a curve prior to entering the curve in Ground 6 of my First Declaration). EX1003, ¶¶99-104, 346. Thus, a POSA would have readily understood that Karlsson-Harbers beam

patterns—like known adaptive beam patterns at the time—would include variation in direction, length, and width (angular distribution) from a bird's eye view, or driver's view with variation in intensity points along a projected distance. Known patterns shown above include large dispersion, curved-road light (bending light, increased lateral illuminance for curves), and high speed long reaching beams as shown above.

158. I note that Dr. Turk acknowledged that Karlsson does in fact control the pattern and direction of its beam pattern in the related '551 patent deposition, which contradicts his position in the Second Turk Declaration. EX1053, 34:19-25 (acknowledging that Karlsson discloses variations of pattern and direction of its light beam). And, when asked during the related '029 patent deposition, Dr. Turk ultimately correctly acknowledged that Karlsson discloses that its beam 50 can (1) vary as regards to its shape and dimension, (2) vary depending on the desired pattern and direction of the beam, and (3) its dimension can vary depending on the desired pattern and direction of the beam. EX1052, 127:4-13; EX1054, 132:15-25, 133:6-7, 134:2-7, 134:13-15. These admissions foreclose Dr. Turk's false premise that Karlsson "us[es] the entire beam array at full intensity, except when avoiding glare." EX2006, ¶88.

159. Dr. Turk even acknowledged during the related '029 patent deposition that Karlsson expressly discloses that its average intensity of the light emitted by

the lighting means is controlled to provide a light beam, the intensity of which is *optimally* adapted to the road and to the ambient light, thereby increasing the driving comfort and road safety. EX1054, 130:7-131:7. And Dr. Turk agrees that "there could be differences in what is considered optimal" depending on road conditions and headlight location. EX1053, 56:7-15.

160. Nothing suggests to a POSA that Karlsson operates with all of its LED spotlight beams at full intensity (per Dr. Turk) except for situations where it implements its glare control function. Such an incorrect reading ignores Karlsson's optimally adapted system with individually and group controllable LEDs resulting in emitted light beam 50 represented as a window that shifts in the plane from left to right and from top to bottom, based on the data from inputs to Karlsson's controller. EX1010, 19:18-20:3.

161. Thus, Karlsson's optimum light effect may be adapted for the driving condition, consistent with Harbers's control system. EX1003, ¶¶344-358

2. Harbers's colored LEDs are compatible with Karlsson.

162. Dr. Turk's assertion that Karlsson's system "creates a color-shifting problem" demonstrates his lack of understanding of the claimed technology. EX2006, ¶206.

163. First, a POSA would have understood how to implement Harbers's colored-LEDs into Karlsson's system to provide a dynamic light beam with

desirable color output. EX1010, 4:10-14, 8:31-34, 10:6-10, and 10:26-28. Specifically, a POSA would have understood how to arrange the different color-LEDs in Karlsson's headlights to reduce "possible color effects for an observer looking into the light emitted by the vehicle headlight." EX1011, 8:30-33. A POSA would have also understood how to configure the optical system in Karlsson-Harbers's system to "effectively mix the colors originating from the LEDs" to prevent any undesirable color-shifts. EX1011, 8:32-34; *see also* EX1006, ¶5 ("[L]ight of different colors is emitted and the partial quantities of the semiconductor light sources are operatable for producing a predetermined color of the light beam exiting the illumination device.").

164. Second, a POSA would have understood that forward illumination of Karlsson's/Harbers's headlights would be within a range of white color—a highly standardized and regulated parameter for automotive lighting—that would not result in the "undesirable color shifts" purported by Dr. Turk. EX2006, ¶238; EX1069, 5-6. While Harbers teaches to provide different colored-LEDs, the light beams generated from each colored light source have "a more or less 'white' appearance." EX1011, 5:27-29. Thus, the rainbow color spectrum shown in Dr. Turk's schematic of Karlsson's modified light beam (EX2006, 238) is inaccurate.

165. Accordingly, combining Harbers's different color LEDs with Karlsson would not create Dr. Turk's purported color-shifting problems

3. My First Declaration explained with sufficient particularity how to combine the teachings of Harbers's software and hardware controls with Karlsson's adaptive headlight system.

166. Dr. Turk contends that Petitioner never explained "which controllable structure" in the Karlsson-Harbers combination "would be controlled by which control function" thereby lacking particularity. EX2006, ¶209. Dr. Turk's argument again shows his lack of understanding in the art.

167. My explanation of how a POSA would combine the teachings of Harbers's software and hardware with Karlsson is straight forward. Karlsson discloses spotlight beams provided by "a grid of separate light sources, such as LEDs," and "a grid of light modulators." EX1010, 14:1-15. Harbers disclose LEDs (opto-electronic elements 11-14) arranged on a curved substrate with pre-aimed segments or angular regions. EX1011, 7:20-8:27. Both of Karlsson's and Harbers's LEDs are controlled individually or in groups to form a "desired" headlight beam pattern. EX1010, 14:1-4 ("LEDs, which can preferably be controlled either individually or in groups."); EX1011, 2:17-18, 4:10-14, 8:21-25, ("by selectively switching on and off a number of opto-electronic elements 11; 12; 13; 14, the light beams generated by the light source 4; 5 can be relatively readily subdivided into one or more beam segments 6, 6'; 7', 7' having a different spatial distribution or substantially different spectral characteristics."). As explained in my First

Declaration over the course of paragraphs [0343]-[0430], the teachings of Harbers's multiple-direction beam segments may be implemented in Karlsson's systems through either software or hardware modifications. EX1003, ¶¶343-359, 373-382.

168. Recognizing that Karlsson's LEDs can be controlled individually or in groups like in Harbers, a POSA would have easily understood that Karlsson and Harbers share common control functionalities to achieve desired beam patterns — high beam with dimmed glare light section, low beam with curved road adaptability, and fog lamp for adverse weather conditions, etc. EX1003, ¶¶352-353, 357-358. Accordingly, a POSA would have understood how to combine Harbers's angular segment controls with Karlsson with no further particularity beyond what was provided in my First Declaration.

E. Karlsson-Harbers combination discloses claim 64.

169. As I explained above in §VII.C., there are no patentable differences between claims 25 and 64, which both recite "wherein at least one of the one or more headlights further includes at least one of reflectors, refractors, or lenses usable to alter the light emitted from at least one of the light sources." EX1001, 98:39-42 (claim 25), 102:57-61 (claim 64). Claim 64 only differs from claim 25 by adding the phrase "as part of the instructed adjustment," which does not patentably distinguish claim 64 from claim 25. EX1001, 98:39-42 (claim 25), 102:57-61

(claim 64). Accordingly, by showing how the Karlsson-Harbers combination discloses the recited "reflectors, refractors, or lenses usable to alter the light emitted from at least one of the light sources" of claim 25, my First Declaration also showed how the Karlsson-Harbers combination discloses the patentably indistinct limitation of claim 64. EX1003, ¶¶435-438.

X. PO'S SUBSTANTIVE ARGUMENTS AGAINST THE KARLSSON-HARBERS-GOTOU COMBINATION FAIL.

170. Road curvature claims 21-23 and 60-62 are addressed by my Sixth Ground, which combines Karlsson, Harbers, and Gotou. EX1003, §§XII-XIII. As explained in my First Declaration, Gotou teaches to control the angular position of the headlight beam according to "map information" obtained from a vehicle navigation system 30. EX1012, 2:1-18, 3:52-67, 6:28-47, FIG. 4; EX1003, ¶¶443-445. My First Declaration makes clear that a POSA would have been motivated to modify Karlsson-Harbers to adjust light beam based on map data, including road curvature, as in Gotou, to illuminate roadway curves more effectively, thereby improving driver safety. EX1003, ¶¶446-460.

171. Dr. Turk argues that it would not have been obvious to combine Gotou's map data control technique with Karlsson-Harbers. First, Dr. Turk alleges Gotou's control functions would conflict with Karlsson and Harbers because steering Karlsson's beam would be obviated by Karlsson's "already existent full illumination." EX2006, ¶232, *see also* ¶¶233-236. Second, Dr. Turk contends that

steering a beam outputted from the Karlsson-Harbers-Gotou combination would create undesirable color shifts. EX2006, ¶¶238-239.

A. Dr. Turk's arguments that Karlsson's grid of spotlight sources default to "full illumination" are incorrect.

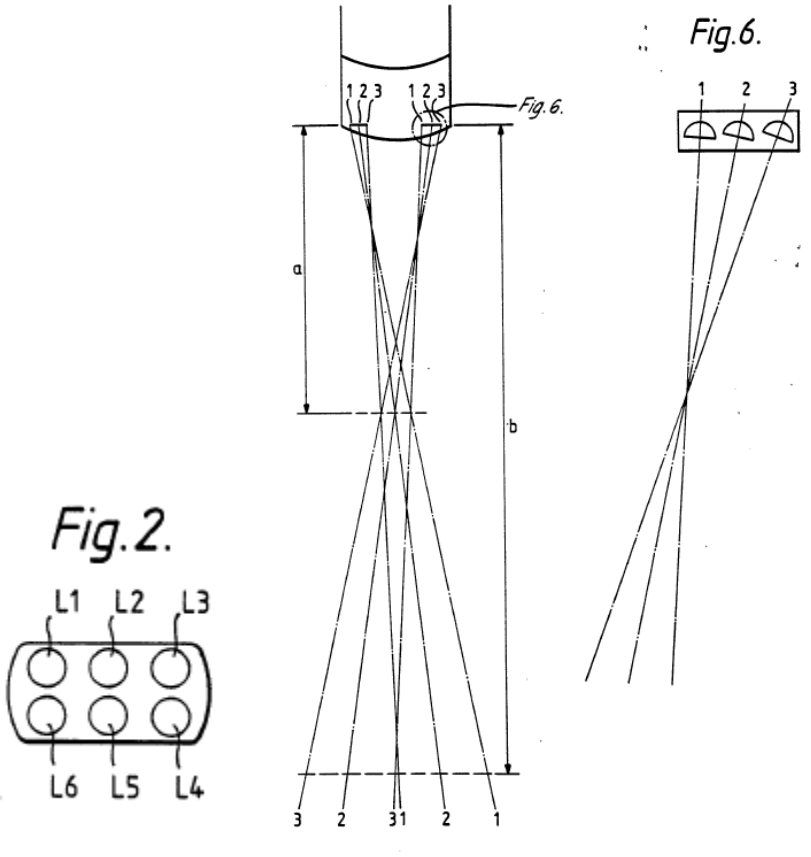
172. Dr. Turk relies on the same mischaracterization of Karlsson—emitted beam 7 is emitted at full intensity everywhere except when avoiding glare—to reach an incorrect conclusion that Karlsson's beam pattern cannot be steered using Gotou's map data technique. EX2006, ¶¶232-236.

173. As I previously explained in §IX.D.3, Dr. Turk's notion that Karlsson operates with all of its LED spotlight beams at full intensity except for glare control is incorrect. Karlsson's "emitted light beam 50 is represented as a window that can shift in the plane of the drawings from the left to the right and from the top to the bottom, if desired, and vice versa, which may vary as regards its shape and dimension in dependence on the desired pattern and direction of the beam." EX1010, 19:29-34. A POSA would have readily understood that Karlsson-Harbers-Gotou beam patterns—like known adaptive beam patterns at the time—would include variation in direction, length, and width (angular distribution) from a bird's eye view, or driver's view with variation in intensity points along a projected distance. Known patterns shown above include large dispersion, curved-road light (bending light, increased lateral illuminance for curves), and high speed long reaching beams, as shown above in §IX.D.3.

174. Further, I note that Dr. Turk also characterizes Flaaten's disclosure, in that it aims for an "*optimum* lighting effect." EX2006, ¶209 (citing EX2017, 1); *see also* EX2006, ¶101 (stating that Flaaten provides an "optimum lighting effect for the driver of the vehicle," citing EX1010, 2:2-9). Indeed, Flaaten describes controlling "the light distribution pattern of the headlights," with "intersecting directions of the axes of light beams," to efficiently dim the light "selectively in the areas where there are other vehicles, persons, or sources of light, whereas a maximum *satisfactory* illumination is maintained of the roadway in front of the vehicle." EX2017, Abstract. Maximum *satisfactory illumination* does not mean *all of Flaaten's light sources are on at all times*. Nor does Flaaten's statement that removing only the portion of the light that would inconvenience the driver of meeting cars support Dr. Turk's conclusion that there should be "full illumination to the 'greatest extent possible.'" EX2006, ¶102. Rather, a POSA would understand that Flaaten expressly acknowledges that "satisfactory illumination is maintained of the roadway in front of the vehicle," for example, including ahead in curves. EX2017, Abstract.

175. To the extent that Dr. Turk thinks Karlsson is an evolution of Flaaten (EX2006, 101), Flaaten shows an array of bulbs in Figures 1 and 2, and gives an example of directional light sources in its arrays in Figures 5 and 6, also including intersecting, combined, optical axes, that together provide light sources "in each

headlight [that] have directions of light that provide the *best possible illumination* in a *desired predetermined area* in front of the vehicle." EX2017, 3:8-14. Flaaten's Figures 2, 5, and 6 are shown for reference:



EX2017, FIGs. 2, 5, and 6.

176. Flaaten's sources L1-L6 are described to be turned off and on, or "dimmed gradually, one at a time." EX2017, 3:34-36. And Flaaten's sources may include an angular setting that is adjustable *automatically*. EX2017, 5:27-31.

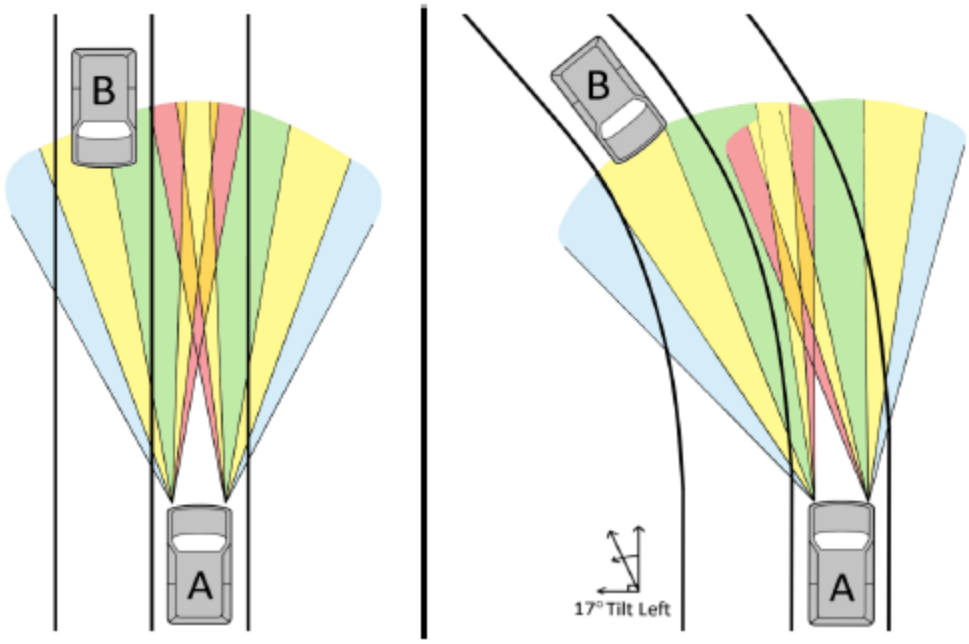
177. Thus, to the extent that Dr. Turk considers Karlsson to be an improvement of a type of device of Flaaten (EX2006, ¶101) or "Karlsson's base device," he appears to acknowledge Karlsson's directionality and aiming of its

spotlight beams from its LEDs—indeed Flaaten itself provides that the roadway, the edges of the road, *curves*, etc. are *satisfactorily* illuminated (EX2017, 2:2-6) and that its system of "intersecting head light beams will also be advantageous when driving in *curves*, since the light beam from left head light will not inconvenience oncoming vehicles, and total dimming of both headlights can be avoided," (EX2017, 2:22-26) by way of "several directional separate headlights in groups," that are "individually dim[m]able" (EX2017, claim 3).

178. In sum, Flaaten would suggest that Karlsson's LED spotlight beams may be aimed to light the *side of the curved road* with more accurate or precise beam pattern control as Karlsson's spotlight beams are smaller headlight beam contributors and can be controlled individually or in groups in comparison to Flaaten's conventional light bulbs. Given a proper understanding of the state-of-the-art, a POSA would have understood that the angular position of Karlsson's emitted beam can be adjusted according to Gotou's techniques, without any conflicts. Thus, a POSA would have been motivated to modify Karlsson-Harbers to adjust the directional light sources to increase illumination of a road curvature by inputting map data to controller, as in Gotou, to improve driver safety. EX1003, ¶¶443-460.

B. The Karlsson-Harbers-Gotou combination would not suffer from color-shifting issues.

179. Dr. Turk's assertion that steering light beam outputted from the Karlsson-Harbers-Gotou combination would create undesirable color shifts shows his lack of a knowledge in the art. EX2006, ¶¶238-239. Dr. Turk's rendering of Karlsson's multi-color segmented beam, reproduced below, indicates his misunderstanding to the art because the so-called "color overlaps" and "color shifts" do not occur.



EX2006, 238: Dr. Turk's Rendering of Karlsson's Color-segmented Beam

180. As I explained above in §IX.C.2, a POSA would have understood how to combine different colored LEDs in a headlight to emit a light beam having a white color, as demonstrated in the background of Thominet. EX1003, ¶¶52, 129;

EX1010, 5:27-28, 8:31-34, 10:6-10, and 10:26-28; EX1006, ¶2, ("The semiconductor light sources emit lights of different colors and each semiconductor light source sends only light of one color… light exiting the illumination device has a uniform, for example *white* color."). Configuring the optical system of a headlight to emit light beams have a white color is well within the level of ordinary skill.

181. While there may be subtle variations of illuminated color within the range, such as bluish white and yellowish white, all light would be recognized as white light (as defined in standards and regulations) that would not result in the "undesirable color shifts" purported by Dr. Turk. EX2006, ¶238; EX1011, 5:27-28 ("It is noted that, in practice, also photopic and scotopic light beams preferably have a broad spectrum, which light beams both have a more or less 'white' appearance."). Dr. Turk's schematic of Karlsson's modified headlight beam, reproduced above, inaccurately exaggerates the degree of color difference between beam segments. A POSA would have understood that Karlsson-Thominet-Gotou's multi-colored beam segments consists of various shades of white light, which would not provide a rainbow color spectrum as purported by Dr. Turk. Thus, there would be no color shifts when steering Karlsson-Harbers's beam in view of Gotou's map data/road curvature control.

C. Karlsson-Harbers-Gotou combination renders every limitation of claims 60-62 obvious.

182. As I explained above in §VIII.B, there are no patentable differences between claims 21-23 and claims 60-62, which both sets of claims are directed to road curvature limitations. EX1001, 98:22-35 (claims 21-23), 102:41-53 (claims 60-62). While claims 21-23 and 60-62 do no recite the exact same claim language, the subject matter of claims 60-62 is not patentably distinct from claims 21-23. As explained in §VIII.B., aiming illumination in a direction of the road curvature (claims 60-62) equates to increasing illumination in a direction of the road curvature (claims 21-23). And directing control circuitry to increase illumination (claims 21-23) would include determining a light output to illuminate the turn (claims 60-62). Specifically, a POSA would have understood an automotive headlight controller would determine a light output before commanding the light source to emit a light beam. Accordingly, by showing how the Karlsson-Harbers-Gotou combination renders obvious the road curvature claims 21-23, my First Declaration also showed how the Karlsson-Harbers-Gotou combination renders obvious the road curvature claims 60-62. EX1003, ¶¶441-472.

XI. CONCLUSION

For at least these reasons, I reach the same conclusions as in my First Declaration—each of the Grounds of unpatentability render all challenged claims of the ’503 patent unpatentable as obvious.

In signing this declaration, I recognize that the declaration will be filed as evidence in an *inter partes* review before the Patent Trial and Appeal Board of the United States Patent and Trademark Office. I also recognize that I may be subject to cross-examination in the case and that cross-examination will take place within the United States. If cross-examination is required, I will appear for cross-examination within the United States during the time allotted.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true, and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code.

Executed on this 5th day of January 2024, in Arlington Virginia.

Dr. Jianzhong Jiao